United States
Department of
Agriculture

Soil
Conservation
Service

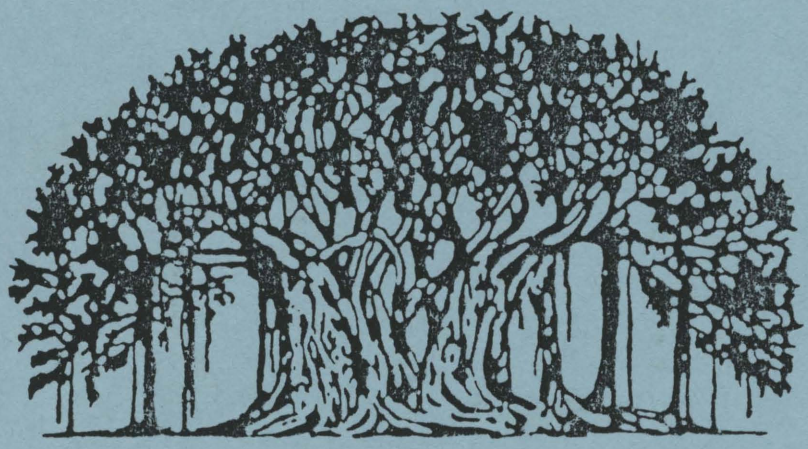
Honolulu,
Hawaii

Draft
Watershed Plan and
Environmental Assessment

December 1990

Lahaina Watershed

Maui County, Hawaii



LAHAINA WATERSHED
COUNTY OF MAUI, HAWAII

DRAFT
WATERSHED PLAN AND ENVIRONMENTAL ASSESSMENT

DECEMBER 1990

Prepared By:

County of Maui
200 S. High Street
Wailuku, Hawaii 96793

West Maui Soil and Water Conservation District
P.O. Box 1170
Wailuku, Hawaii 96793

United States Department of Agriculture
Soil Conservation Service
(Lead Agency)

For additional information contact:

Warren M. Lee, State Conservationist
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Honolulu, Hawaii 96850
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ABSTRACT

This document describes a plan for flood protection. Alternatives considered during planning included no action, nonstructural, and structural measures. Except for the no action alternative, all of the alternative plans propose the installation of a flood water diversion channel to alleviate the flooding problem. Net economic benefits are maximized in the Recommended Plan. Annualized project costs are estimated to be $475,500. Environmental impacts include a 1,200 ton per year reduction in total sediment discharge to the ocean and a 50-year level of flood protection provided to the agricultural, residential, and commercial areas of the lower Lahaina Watershed which includes the Lahaina Historic District. Annualized project benefits are estimated to total $563,100. This document fulfills the requirements of the National Environmental Policy Act, the Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, and the Soil Conservation Service's National Watersheds Manual. The Plan also serves as a basis for authorization of Public Law 83-566 funding.

Prepared under the authority of the Watershed Protection and Flood Prevention Act, Public Law 83-566, as amended (16 U.S.C. 1001-1008) and in accordance with the National Environmental Policy Act of 1969, Public Law 91-190, as amended (42 U.S.C. 4321 et seq.)

WATERSHED AGREEMENT

between the

COUNTY OF MAUI

and

WEST MAUI SOIL AND WATER CONSERVATION DISTRICT

State of Hawaii

(referred to herein as Sponsors)

and the

SOIL CONSERVATION SERVICE

United States Department of Agriculture

(referred to herein as SCS)

Whereas, application has heretofore been made to the Secretary of Agriculture by the Sponsors for assistance in preparing a plan for works of improvement for the Lahaina Watershed, State of Hawaii, under the authority of the Watershed Protection and Flood Prevention Act (16 U.S.C. 1001-1008); and

Whereas, the responsibility for administration of the Watershed Protection and Flood Prevention Act, as amended, has been assigned by the Secretary of Agriculture to SCS; and

Whereas, there has been developed through the cooperative efforts of the Sponsors and SCS a plan for works of improvement for the Lahaina Watershed, State of Hawaii, hereinafter referred to as the Watershed Plan-Environmental Assessment, which plan is annexed to and made a part of this agreement;

Now, therefore, in view of the foregoing considerations, the Secretary of Agriculture, through SCS, and the Sponsors hereby agree on this plan and that the works of improvement for this project will be installed, operated, and maintained in accordance with the terms, conditions, and stipulations provided for in this watershed plan and include the following:

1. Landrights: The County of Maui will acquire, with other than P.L. 566 funds, such landrights as will be needed in connection with the works of improvement.

Land Rights	County of Maui (percent)	SCS (percent)	Estimated Landrights Payment Costs (dollars)
	100	0	892,200

2. Relocation Payments and Assurances: The County of Maui hereby agrees that it will comply with all of the policies and procedures of the Uniform Relocation Assistance and Real Property Acquisition Policies Act (42 U.S.C. 4601 et. seq. as implemented by 7 C.F.R. Part 21) when acquiring real property interests for this federally assisted project. If the County of Maui is legally unable to comply with the real property acquisition requirements of the Act, it agrees that, before any federal financial assistance is furnished, it will provide a statement to that effect, supported by an opinion of the chief legal officer of the state containing a full discussion of the facts and law involved. This statement may be accepted as constituting compliance. In any event, the County of Maui agrees that it will reimburse owners for necessary expenses as specified in 7 C.F.R. 21, 1006 (c) and 21.1007.

The cost of relocation payments in connection with the displacements under the Uniform Act will be shared by the County of Maui and SCS as follows:

Relocation Payments	County of Maui (percent)	SCS (percent)	Estimated Relocation Payment Costs (dollars)
	19	81	250,000

3. Permits: The County of Maui will obtain all necessary federal, state, and local permits required by law, ordinance, or regulation for installation of works of improvement.

4. Construction Costs: The percentages of construction costs to be paid by the County of Maui and by SCS are as follows:

Works of Improvement	County of Maui (percent)	SCS (percent)	Estimated Construction Costs (dollars)
All Structural Measures	0	100	3,799,500

5. Engineering Services Costs: The percentages of the engineering services costs to be borne by the County of Maui and SCS are as follows:

Works of Improvement	County of Maui (percent)	SCS (percent)	Estimated Engineering Services Costs (dollars)
All Structural Measures	0	100	398,900
Construction Inspection			171,000

The County of Maui and SCS will bear the cost of construction inspection that each incurs.

6. Project Administration: The County of Maui and SCS will each bear the costs of project administration that each incurs. The percentages of project administration costs to be borne by the County of Maui and SCS are estimated to be as follows:

Project Administration	County of Maui (percent)	SCS (percent)	Estimated Project Administration Costs (dollars)
	50	50	304,000

7. Floodplain Management and Flood Insurance: The County of Maui agrees to participate in and comply with applicable Federal floodplain management and flood insurance programs before construction starts.

8. Operation, Maintenance, and Replacement: The County of Maui will be responsible for the operation, maintenance, and replacement of the works of improvement by actually performing the work or arranging for such work, in accordance with agreements to be entered into before issuing invitations to bid for construction work. Average annual operation, maintenance, and replacement costs are estimated to be $45,400.

10. Costs: The costs shown in this plan are preliminary estimates. Final costs to be borne by the parties hereto will be actual costs incurred in the installation of works of improvement.

11. Funding: This agreement is not a fund-obligating document. Financial and other assistance to be furnished by SCS in carrying out the plan is contingent upon the fulfillment of applicable laws and regulations and the availability of appropriations for this purpose.

12. Financial Agreements: A separate agreement will be entered into between SCS and the County of Maui before either party initiates work involving funds of the other party. Such agreements will set forth in detail the financial and working arrangements and other conditions that are applicable to the specific works of improvement.

13. Plan Revision: This plan may be amended or revised only by mutual agreement of the parties hereto, except that SCS may deauthorize or terminate funding at any time it determines that the Sponsors have failed to comply with the conditions of this agreement. In this case, SCS shall promptly notify the Sponsors in writing of the determination and the reasons for the deauthorization of project funding, together with the effective date. Payments made to the Sponsors or recoveries by SCS shall be in accord with the legal rights and liabilities of the parties when project funding has been deauthorized. An amendment to incorporate changes affecting a specific measure may be made by mutual agreement between SCS and the sponsor(s) having specific responsibilities for the measure involved.

14. Conflict of Interest: No member of or delegate to Congress, or resident commissioner, shall be admitted to any share or part of this plan, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporate for its general benefit.

15. Nondiscrimination: The program conducted will be in compliance with all requirements respecting nondiscrimination, as contained in the Civil Rights Act of 1964, as amended, and the regulations of the Secretary of Agiculture (7 CFR 15), which provide that no person in the United States shall, on the grounds of race, color, national origin, sex, age, handicap, or religion, be excluded from participation in, be denied the benefits of, or otherwise be subjected to discrimination

under any program or activity conducted or assisted by the Department of Agriculture.

16. Drug-Free Workplace: The Sponsors will certify that conditions for Drug-Free Workplace pursuant to the Drug-Free Workplace Act of 1988 (P.L. 100-690, Title V, Subtitle D) are met. Certification will be made on Form AD-1049 when the Watershed Agreement is signed.

COUNTY OF MAUI
200 S. High Street
Wailuku, Hawaii 96793

By: _____
Hannibal M. Tavares
Mayor

Date: _____

The signing of this plan was authorized by a resolution of the governing body of the County of Maui adopted at a meeting held on _____.

_____

Name and Title: _____

Date: _____

200 S. High Street
Wailuku, Hawaii 96793

WEST MAUI SOIL AND WATER
CONSERVATION DISTRICT
P.O. Box 1170
Wailuku, Hawaii 96793

By: _____
David Nobriga
Chairman

Date: _____

The signing of this plan was authorized by a resolution of the governing body of the West Maui Soil and Water Conservation District adopted at a meeting held on _____.

_____
Espie Asuncion, Secretary

Date: _____

P.O. Box 1170
Wailuku, Hawaii 96793

SOIL CONSERVATION SERVICE
United States Department of Agriculture

Approved by: _____
Warren M. Lee
State Conservationist

Date: _____

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SUMMARY

Project Name: Lahaina Watershed, County of Maui, Hawaii

Sponsors: County of Maui

West Maui Soil and Water Conservation District

Description of Recommended Plan: The plan proposes the installation of a floodwater diversion channel that starts at Lahainaluna Road, extends across the Lahaina subwatershed, and outlets into Kauaula Stream. Other measures include a debris basin and improvements to the Kauaula Stream outlet channel. The measures will provide a 50-year level of flood protection to a 100-year floodplain benefitted area which includes 168 homes, 152 businesses, two schools, two parks, and 80 acres of irrigated sugarcane.

Resource Information:

Watershed Size:	4,920 acres	
Land Use:	Urban	440 acres
	Irrigated Sugarcane	1,080 acres
	Forest Reserve and Brush Land	3,400 acres
HEL Cropland:		360 acres
Land Ownership:	Private	79 percent
	State of Hawaii	21 percent

Number of Farms: 1, Pioneer Mill Company with 1,080 acres of its 9,000-acre sugar plantation located in the Lahaina Watershed

Prime Farmland: 205 acres

Other Important Agricultural Land: 1100 acres

Project Beneficiary Profile: Commercial and service businesses supporting a visitor industry and one corporate sugar plantation operation. In the residential area, there is a broad mix of homeowners, homeowners on leasehold property, and renters.

Wetlands: None Identified

Floodplain Land Use: Urban 130 acres

Irrigated Sugarcane 80 acres

Threatened or Endangered Species: None Identified

Cultural Resources: Lahaina Historic District included on National Register and State Register of Historic Places

Problem Identification: Flooding is the main problem in the Lahaina Watershed. Floodwater and sediment damage occurs to homes, businesses, and roads in Lahaina Town and to sugarcane crops, fields, roads, irrigation systems, and ditches. Average annual flood damage amounts to $585,300 for urban properties, $4,200 for infrastructure, and $10,700 for agriculture. Floodproofing costs for new construction is estimated to average $71,500 annually. Sediment-laden storm runoff turns the nearshore ocean waters a reddish-brown color resulting in income losses for ocean-front hotels and ocean-based businesses, reduced recreational opportunities, and reduced visitor appeal of the Lahaina area. Average annual income losses due to "red water" have been estimated at $107,900. Sedimentation and floodwater runoff are also recognized as a threat to the coral reef ecosystems.

Candidate Plans Considered: A structural alternative that utilizes a floodwater diversion channel and a "no action" alternative were designated as candidate plans and considered by the sponsors before selection of a Recommended Plan.

Project Purpose: The major project purpose is flood prevention.

Principal Project Measures of Recommended Plan:

Project installation will include:

1. Construction of a 6,824-foot long floodwater diversion channel from Lahainaluna Road to Kauaula Stream. 1,024 feet of the channel would be reinforced concrete and 5,800 feet would be earth. Associated structures include an inlet basin, an energy dissipating basin, and three sediment basins.

2. Construction of a debris basin at Kauaula Stream to capture cobble- to boulder-sized rocks.

3. Replacement of the Kauaula Stream cement rock masonary outlet channel with a rectangular reinforced concrete channel.

Project Costs:

Cost Item	PL-566 Funds $	PL-566 Funds %	Other Funds $	Other Funds %	Total $
Structural Measures for Flood Prevention	3,799,500	100	0	0	3,799,500
Engineering	569,900	100	0	0	569,900
Project Administration	152,000	50	152,000	50	304,000
Land Rights	0	0	892,200	100	892,200
Household Relocation	202,500	81	47,500	19	250,000
Total	4,723,900	81	1,091,700	19	5,815,600

Annual Project Benefits:	Agriculture	$ 9,600
	Urban (includes Public Agency)	590,900
	Red Water Pollution	69,200
	Total	$669,700
Acres Benefitted:	Agriculture	80 acres
	Urban	130 acres
	Total	210 acres
Number of Buildings Fully Protected: (50-Year Storm)	Residences	98
	Commercial	20
	Total	118
Number of Buildings Partially Protected: (50-Year Storm)	Residences	61
	Commercial	114
	Public	2
	Total	177

Impacts:

Land Use Changes: Approximately 20.4 acres of land will be required for installation of the diversion channel and related structures.

Natural Resources Changed or Lost: Quality of nearshore marine environment will be improved. Total sediment discharge to the ocean from the watershed will be reduced. Sediment discharge to fringing reef area will be nearly eliminated. The average annual fine sediment discharge at Kauaula Stream will be increased. The Kauaula Stream outlet is a naturally formed stream mouth and was determined to be the site least impacted by additional sediment discharge.

Approximately eight acres of prime farmland and ten acres of other important farmland will be lost due to installation of the diversion channel.

Major Conclusions: There is a potential for great economic loss from flooding and sedimentation in the Lahaina Watershed due to the high valuation of the watershed's resources. The alternative plan that alleviates the watershed's problems and results in the greatest amount of net benefits was selected as the recommended plan.

Areas of Potential Controversy: (Statement will appear in the Final Plan-EA.)

Issues to be Resolved: (Statement will appear in the Final Plan-EA.)

INTRODUCTION

General

The purpose of this Watershed Plan and Environmental Assessment (Plan-EA) is to appraise the economic feasibility and environmental acceptability of providing flood protection to urban and agricultural properties in the Lahaina Watershed. The plan describes the watershed's problems and resources, the plan formulation process, the recommended plan, and the expected environmental and economic impacts. This plan also provides the basis for authorizing federal assistance for implementation.

This plan was prepared under the authority of the Watershed Protection and Flood Prevention Act, Public Law 83-566 (PL-566), as amended (16 U.S.C. 1001-1008) and is in accordance with Section 102(2)(C) of the National Environmental Policy Act of 1969, Public Law 91-190, as amended (42 U.S.C. 4321 et seq.). Responsibility for compliance with the National Environmental Policy Act rests with the U.S. Department of Agriculture Soil Conservation Service (SCS).

The Soil Conservation Service provided technical assistance to the Sponsors, the County of Maui and the West Maui Soil and Water Conservation District, in the development of this plan. Other federal, state, and local agencies, along with private groups and individuals, participated in the planning process by providing data, developing project concepts, and reviewing project alternatives.

Reader's Guide

The format of this plan is directed by various regulations and guidelines. This reader's guide outlines the planning process and assists the reader in finding items of particular interest. Appendix D is the Project Map which can be used for reference while reviewing this plan.

Planning was initiated by the Sponsors' request for SCS assistance in solving the water and related land resource problems in the Lahaina Watershed. The SCS and the Sponsors followed a project planning process that involved six basic steps:

1. Identify problems and opportunities.
2. Inventory resources and forecast future conditions.
3. Formulate alternative plans.
4. Evaluate effects of the alternatives.
5. Compare the alternatives.
6. Select a recommended plan.

The project planning process will produce Technical Review, Draft, and Final copies of the Plan-EA. At each review step, reviewer comments are incorporated or reconciled.

An environmental evaluation was also conducted throughout the development of the Plan-EA to assess the significance of the plan's effects on the human environment. Environmental and social concerns of the community were identified through the public participation process.

The Watershed Agreement, included at the front of this report, is the culmination of the planning effort and serves as the formal acceptance of

the Plan-EA by the Sponsors and SCS. Funding for project installation is not obligated by the Agreement.

The Contents lists the principal topics contained in this Plan-EA.

The Summary describes the Plan-EA in brief. It should not be used as the sole source of information if a complete understanding of the project is desired.

Project Setting begins the main body of the Plan-EA by describing the Lahaina Watershed and its resources in general terms.

Problem and Opportunity Identification describes and quantifies problems that need to be solved as well as opportunities for enhancing the quality of life in the project area based on public concerns. Table A - Problems and Opportunities provides a summary of this information.

Inventory and Forecasting identifies concerns significant in the formulation of alternatives, evaluates existing resources, and presents a forecast of future conditions without the project. Table B - Evaluation of Identified Concerns lists each concern and its degree of significance to decisionmaking.

Formulation of Alternatives describes the formulation of alternative plans and the rationale for selection of the recommended plan. Table E - Summary and Comparison of Candidate Plans presents a tabular comparison of the candidate plans.

The next two sections, Recommended Plan and Effects of the Recommended Plan, describe the plan proposed for implementation and its effect on the

economy and human environment. The following tables present pertinent data covered in these two sections:

Table 1 - Installation Costs

Table 2 - Estimated Cost Distribution

Table 3 - Structural Data

Table 4 - Annualized Adverse National Economic Development Effects

Table 5 - Estimated Annualized Flood Damage Reduction Benefits

Table 6 - Comparison of NED Benefits and Costs.

Appendices contain Letters and Oral Comments (A), Support Maps (B), Investigation and Analyses Report (C), and Project Map (D).

Questions and comments regarding this plan should be referred to:

Warren M. Lee, State Conservationist
U.S. Department of Agriculture, Soil Conservation Service
P.O. Box 50004
Honolulu, Hawaii 96850
Telephone: (808) 541-2600.

PROJECT SETTING

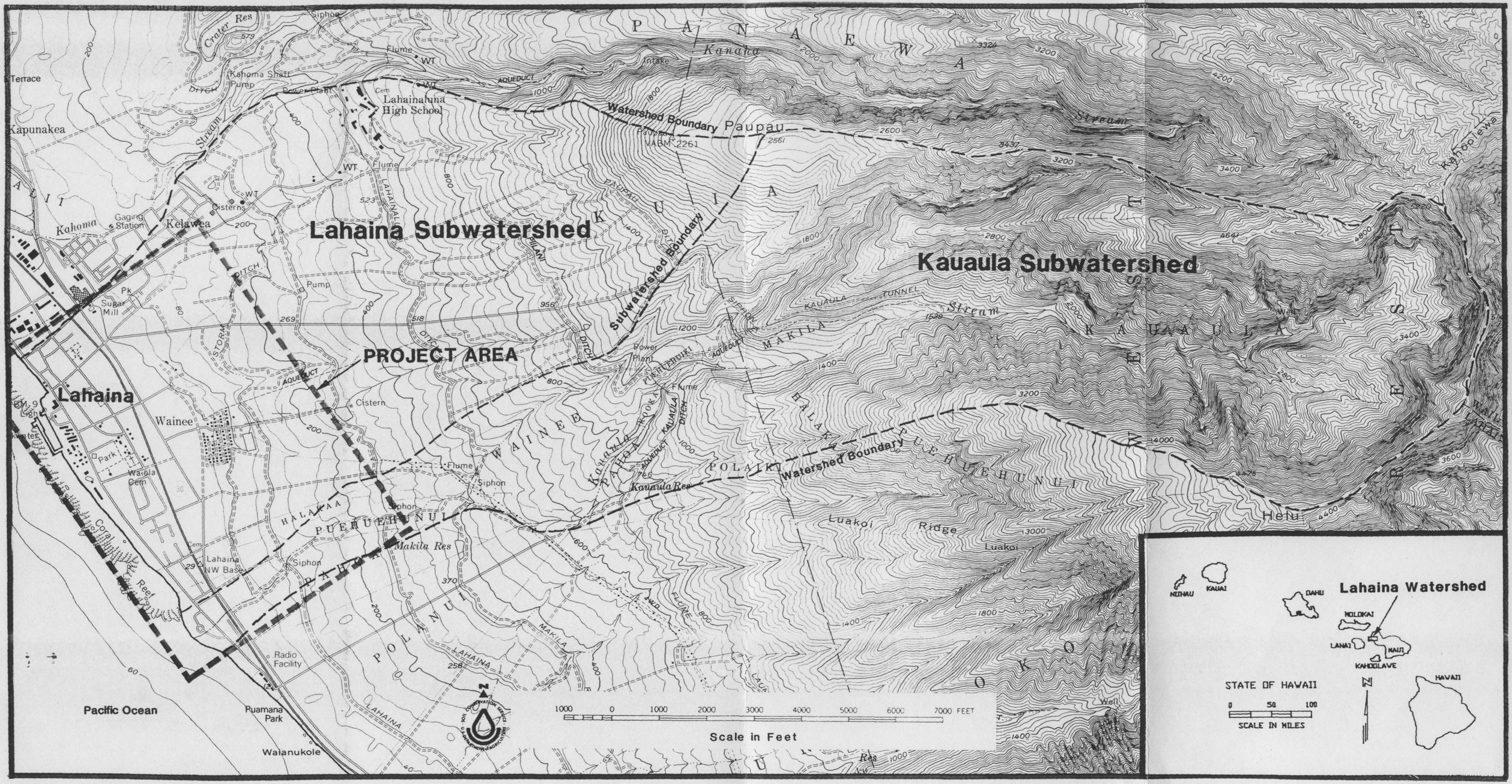
Size and Location

The Lahaina Watershed is located in Maui County, Hawaii. The watershed is in the Lahaina District on the island of Maui, second largest of the eight major islands in the Hawaiian Archipelago. (Figure A - Watershed Map) The watershed is 4,920 acres in area and includes two subwatersheds, the 2,140-acre Lahaina subwatershed and the 2,780-acre Kauaula subwatershed.

Land Use and Ownership

Of the 4,920 acres in the watershed, 440 acres are in urban uses such as residential and commercial, 1,080 acres are used for the production of sugarcane, and 3,400 acres are in forest and brushland. (Figure B - Land Use Zoning) The major residential and commercial areas located along the coastline include the southern part of Lahaina Town and the Puamana subdivision. Sugarcane dominates the landscape from elevation 50 feet to 1,400 feet. The 1,080 acres used for the production of sugarcane is part of the 9,000 acre Pioneer Mill Company plantation which stretches along the coastline of West Maui from Papalaua to Kahana. The upper watershed area is forest reserve and brushland.

Approximately 3,870 acres or 79 percent of the land in the watershed is privately owned and 1,050 acres or 21 percent is owned by the State of Hawaii. (Figure C - Land Ownership) The major private landowners in the watershed are AMFAC, Inc., the parent company of Pioneer Mill Company, with 2,205 acres and the Bishop Estate with 1,185 acres.



Source: LAHAINA QUADRANGLE, U. S. Geological Survey

Figure A

WATERSHED MAP

Lahaina Watershed, Maui County, Hawaii

Figure B

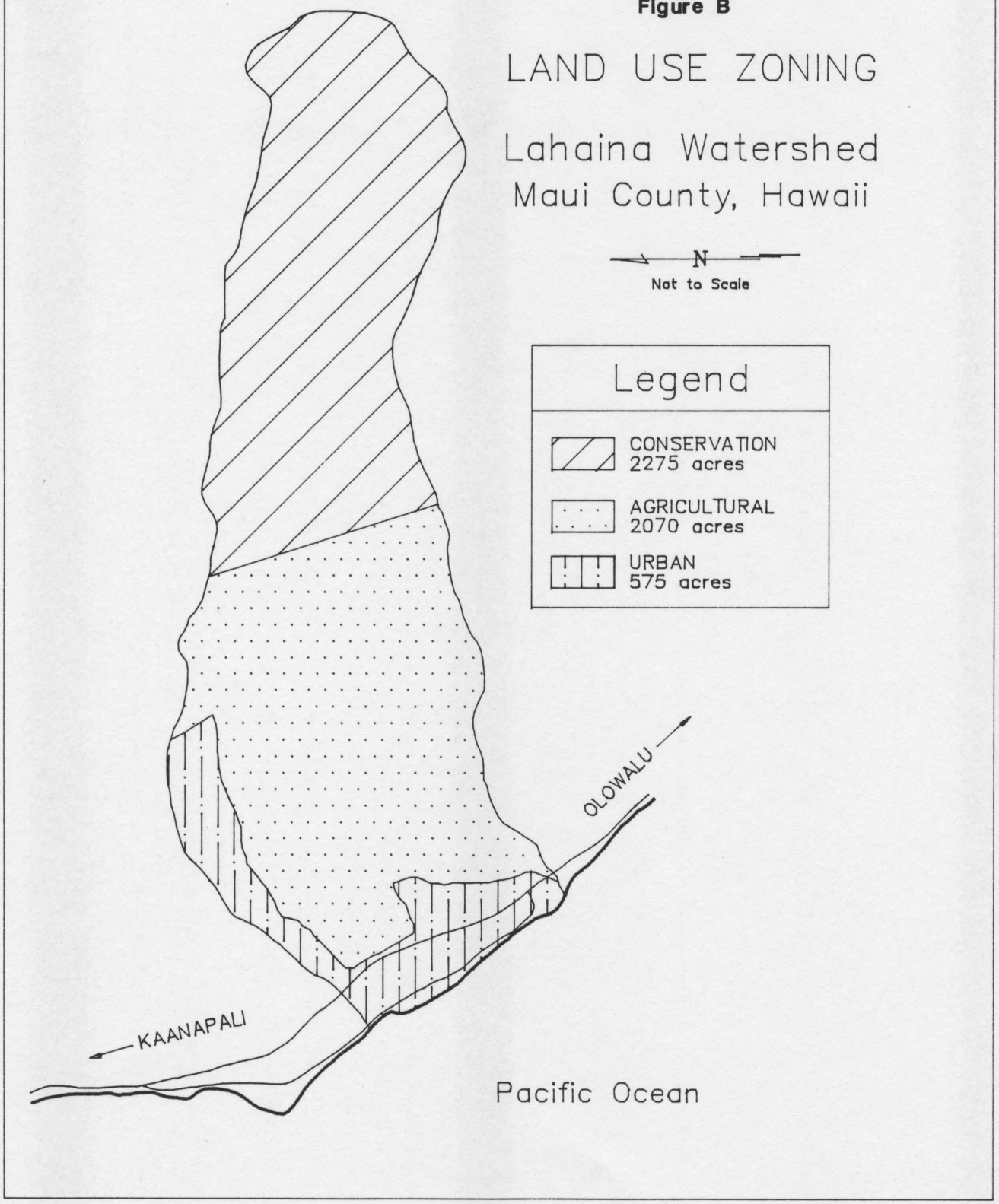

LAND USE ZONING
Lahaina Watershed
Maui County, Hawaii
N
Not to Scale
Legend
CONSERVATION
2275 acres
AGRICULTURAL
2070 acres
URBAN
575 acres
OLOWALU
KAANAPALI
Pacific Ocean

Figure C

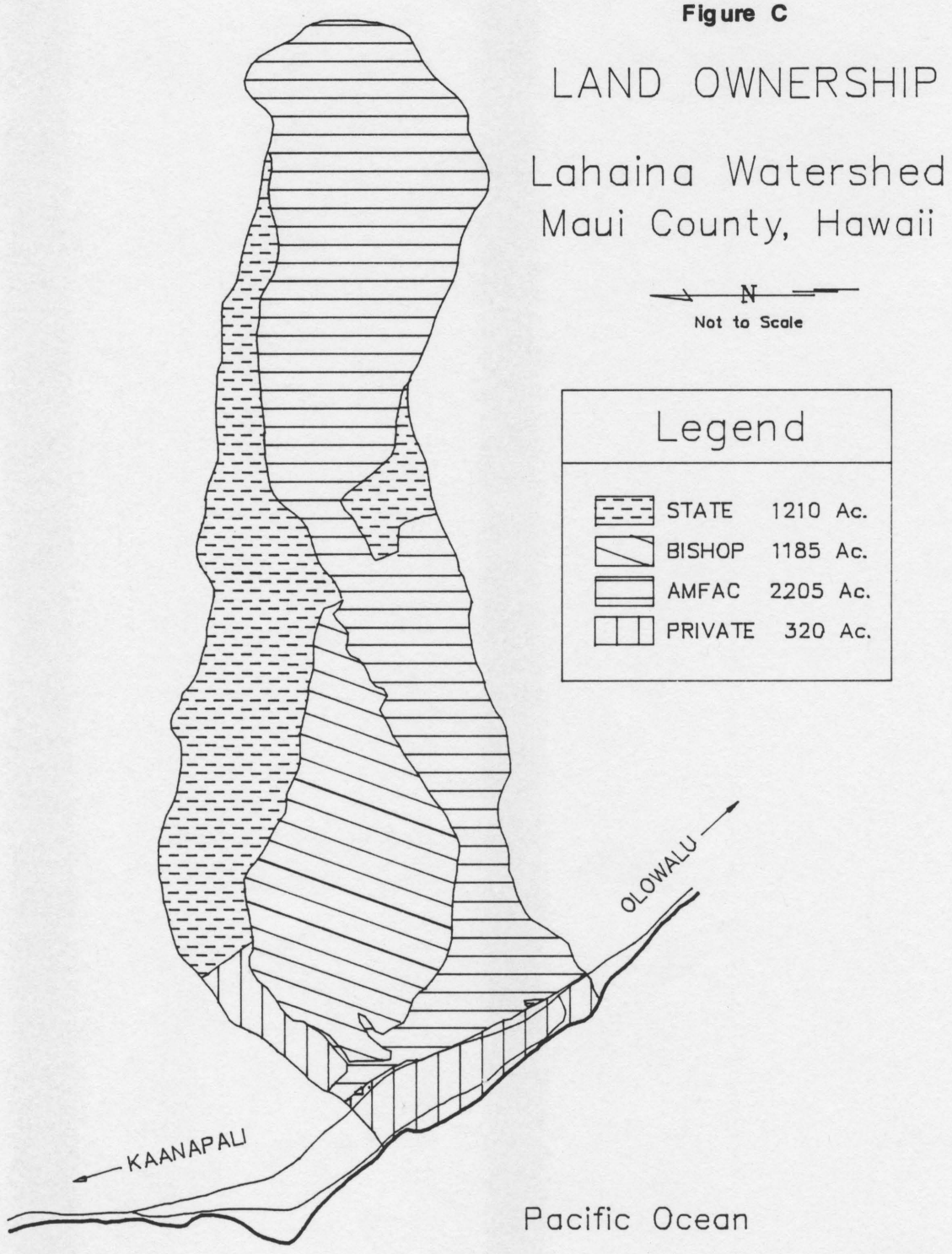

LAND OWNERSHIP
Lahaina Watershed
Maui County, Hawaii
N
Not to Scale
Legend
STATE 1210 Ac.
BISHOP 1185 Ac.
AMFAC 2205 Ac.
PRIVATE 320 Ac.
OLOWALU
KAANAPALI
Pacific Ocean

Figure D

GEOLOGIC MAP

Lahaina Watershed
Maui County, Hawaii

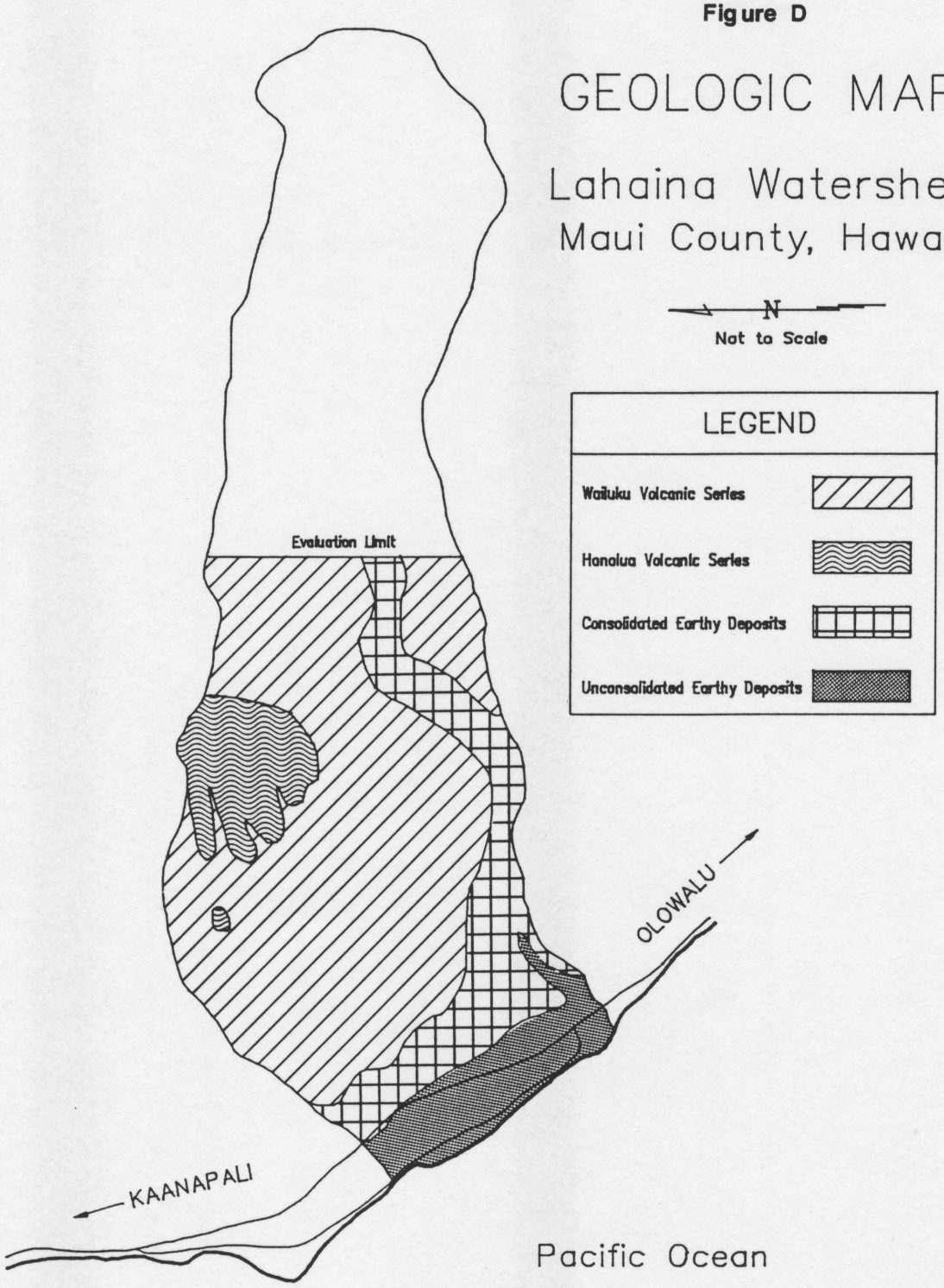


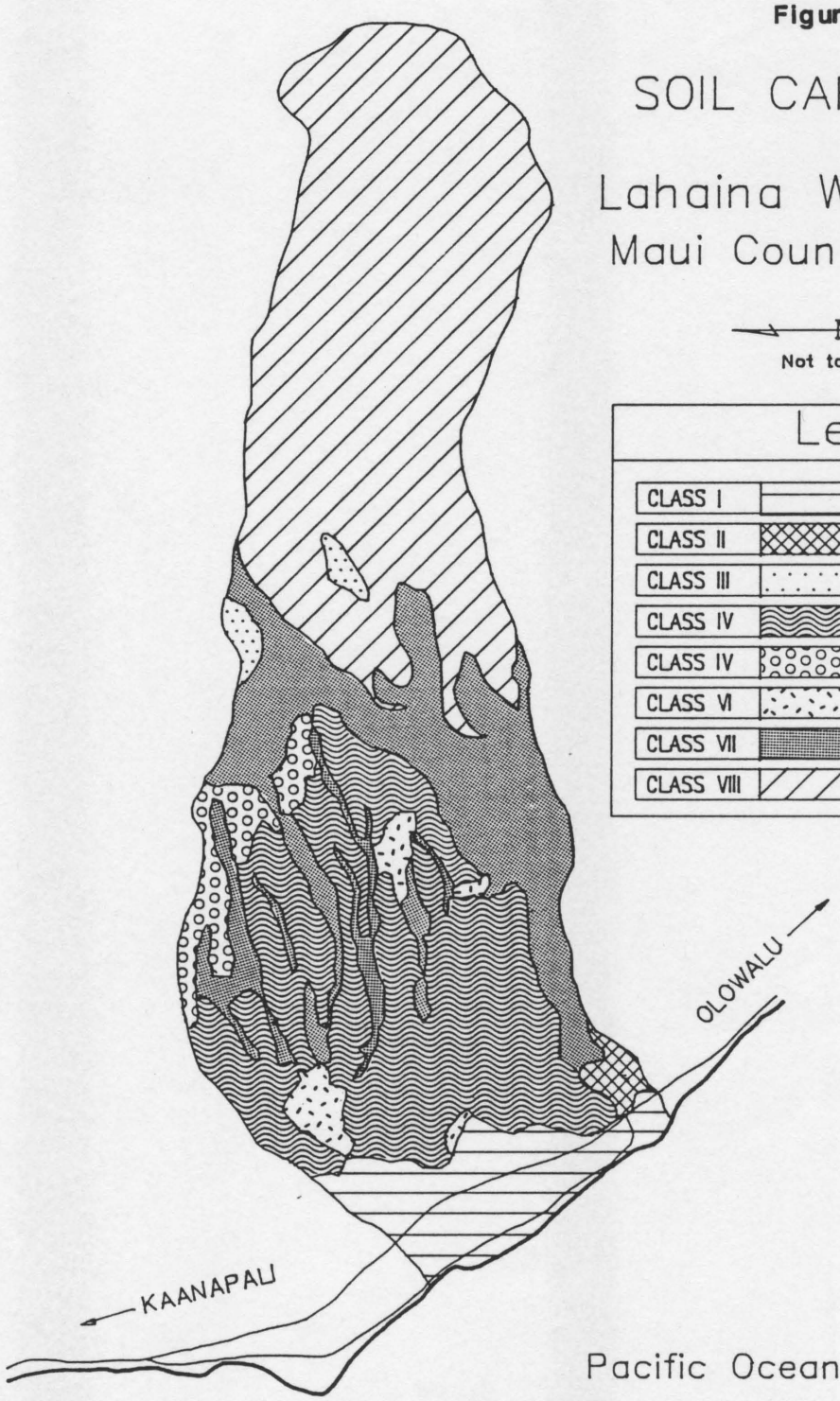
Figure E

SOIL CAPABILITY

Lahaina Watershed
Maui County, Hawaii

N

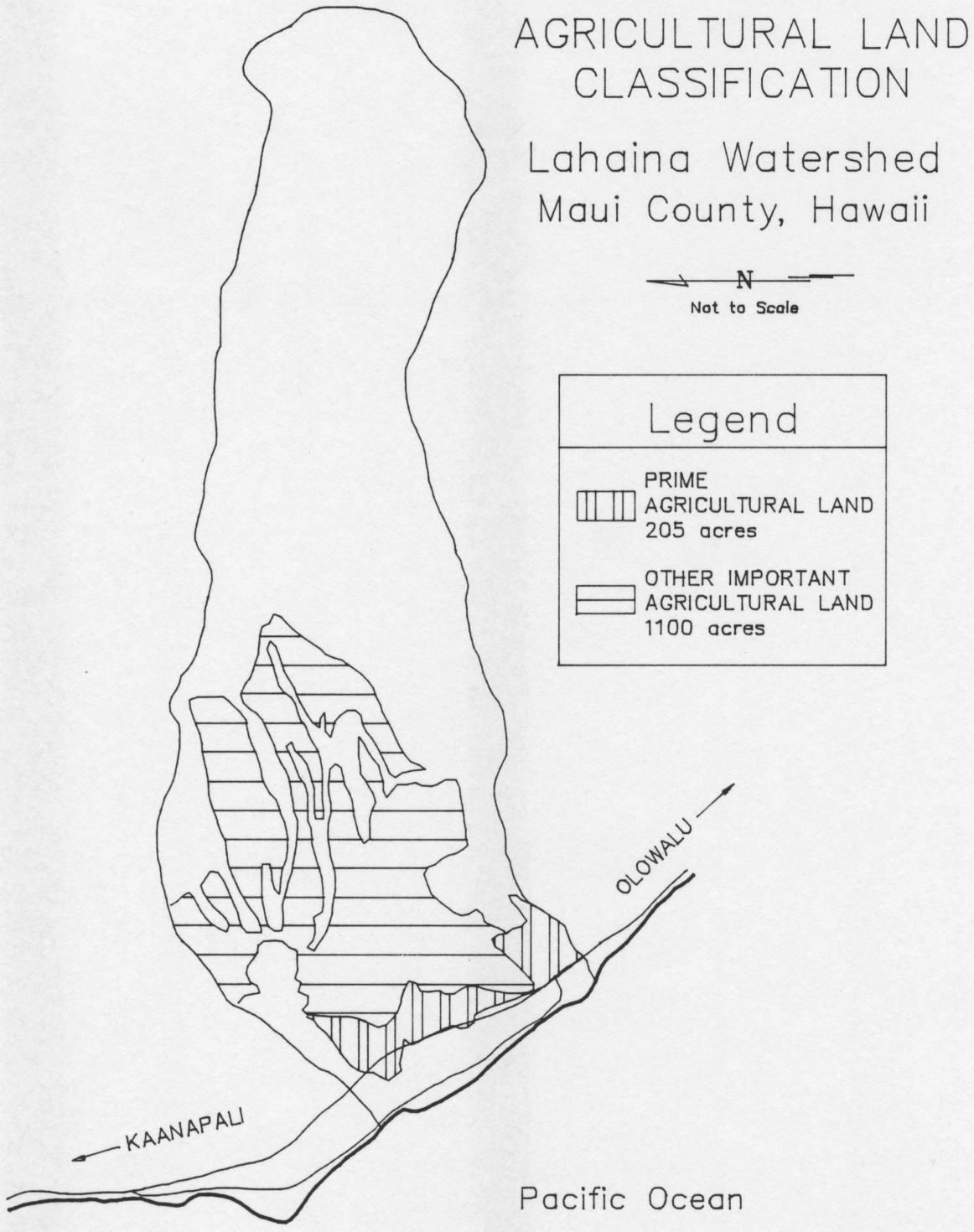
Not to Scale



Legend

CLASS I		EWA	370 Ac.
CLASS II		PULEHU	45 Ac.
CLASS III		OLELO	78 Ac.
CLASS IV		WAINEE	109 Ac.
CLASS IV		LAHAINA	196 Ac.
CLASS VI		WAINEE	1096 Ac.
CLASS VII		ROCK LAND	951 Ac.
CLASS VIII		ROUGH MTS	2075 Ac.

Figure F


AGRICULTURAL LAND CLASSIFICATION
Lahaina Watershed
Maui County, Hawaii
N
Not to Scale
Legend
PRIME AGRICULTURAL LAND 205 acres
OTHER IMPORTANT AGRICULTURAL LAND 1100 acres
OLOWALU
KAANAPALI
Pacific Ocean

Topography

The Lahaina subwatershed rises from the Pacific Ocean to 2,561 feet mean sea level (MSL) and the Kauaula subwatershed from the ocean to 5,220 feet MSL. (Figure A - Watershed Map) The coastal areas of both subwatershed are relatively flat and have been developed for residential and commercial uses. The area above the developed flatland to about the 1,400 foot elevation is gently sloping and is used for growing sugarcane. The sugarcane fields have an average slope of ten percent. The remaining upper area of the Lahaina subwatershed is steep and is used for sugarcane or pasture. The upper portion of the Kauaula subwatershed is mountainous with deeply incised canyons and is part of the West Maui Forest Reserve.

Drainage Patterns

There are no streams or large defined drainageways in the Lahaina subwatershed. Runoff generated in the sugarcane fields above Lahaina Town is conveyed by numerous small drainageways through sugarcane fields and roads, over Honoapiilani Highway, and into Lahaina Town where it ponds in low spots or drains into the Pacific Ocean. The storm drain system within Lahaina Town consists of short, small capacity culverts with grated inlets along roadsides that outlet to the ocean. Runoff ponds in the low-lying area around Maluuluolele Park and the commercial areas along Front Street and Wainee Street. The ponded runoff dissipates through infiltration and evaporation.

Kauaula Stream is the major drainage through the Kauaula subwatershed. The stream, which originates on the western slopes of the West Maui mountains, follows a westerly course through the subwatershed discharging into the

ocean at the Puamana residential subdivision located at Makila Point. The upper reaches of the stream are perennial. The Pioneer Mill Company maintains an irrigation water diversion at 1,500 feet MSL. The lower reaches are dry, except during periods of heavy rainfall.

Climate

The watershed has a very steep rainfall gradient due to the proximity of the mountains to the ocean. Average annual rainfall varies from 15 inches at the coast to 300 inches in the mountains only four miles inland. The heaviest rains are usually brought by winter storms, occuring between October and April.

Average annual temperature in Lahaina Town is about 75 degrees F. Average monthly temperatures vary by about nine degrees between the coolest and warmest months. Prevailing trade winds blow from the northeast throughout the year at an average speed of about ten miles per hour.

Geology

The island of Maui consists of two major volcanic mountains forming East and West Maui. Haleakala, on East Maui, is 10,025 feet high and 33 miles across. West Maui, the older volcano, is 5,788 feet high and 18 miles across. The Lahaina Watershed is part of the West Maui mountains.

Volcanic rocks of the West Maui volcano are divided into three series. (Figure D - Geologic Map) The oldest series, the Wailuku Volcanic Series, is basaltic flows that built the major shield of the volcano. The Honolua Volcanic Series covered the Wailuku Series with thin andesitic and

trachytic flows, domes and pyroclastic deposits. After a period of quiescence and erosion, eruptions produced the Lahaina Volcanic Series.

The major geologic units in the watershed consists of the Wailuku and Honolua volcanic series. The Wailuku series is predominantly thin pahoehoe and aa lava flows. This shield reached a height of about 7,000 feet above sea level before the top collapsed, forming a caldera about two miles in diameter. Lavas of the Honolua Series are mostly aa, although some are pahoehoe.

The West Maui volcano is a "central" type where dikes radiate in all directions from the central vent at the summit, giving the volcano its nearly circular ground plan. Lava beds on this volcano poured out of the central vent and are relatively steep. The rift zones of this volcano are less pronounced than most other Hawaiian volcanoes. There is a concentration of dikes in two zones, one crossing the volcano in a north-south direction and the other trending northeast in the northeast part of the mountain.

Soils

The major soils in the watershed are Ewa silty clay loam with zero to three percent slopes, various soils in the Wainee series, and Rough mountainous land. (Figure E - Soil Capability) The Ewa soil is located in the relatively flat coastline areas developed for residential and commercial uses. Most of the area planted in sugarcane consists of Wainee soils. The upper half of the watershed is mostly Rough mountainous land.

The Ewa soil is well-drained. Runoff on this soil is very slow and erosion hazard is slight.

The Wainee soils are well-drained extremely stony or very stony silty clay soils. Runoff on these soils is slow to medium and erosion hazard is slight to moderate.

Rough mountainous land consists of very steep land broken by numerous intermittent drainage channels. Over much of the area, the soil mantle is between one to 10 inches thick. The land surface is dominated by deep, V-shaped valleys that have extremely steep side slopes and narrow ridges between the valleys. In most places the local relief exceeds 500 feet. Rock land, rock outcrop, soil slips, and eroded spots make up 20 to 40 percent of the acreage.

Basic Social and Economic Conditions

In Lahaina, residential, commercial, and resort developments are gradually displacing agricultural land uses in the relatively flat coastal areas. From 1970 to 1980, the resident population in the town of Lahaina increased from 3,718 to 6,095, an increase of over 60 percent.

Tourism is the primary industry on Maui and in the Lahaina watershed. Lahaina Town is a major tourist destination with numerous clothing and food stores, gift shops, fast-food outlets, and restaurants targeting the visitor market. Several hotels and condominiums provide accommodations for visitors in the watershed. Many ocean recreation businesses base their operations around the Lahaina Boat Harbor.

The production of sugarcane and milling of raw sugar is the second most important industry in the watershed. The Pioneer Mill Company plantation is about 9,000 acres in size, 1,080 acres of which are located within the watershed. Most of the sugar land is designated Prime Agricultural Land or

Other Important Agricultural Land by the State of Hawaii in their inventory of Agricultural Lands of Importance to the State of Hawaii. (Figure F - Agricultural Land Classification)

The Pioneer Mill Company employs about 300 workers, most of whom live in or near Lahaina.

Lahaina Town is also regarded as the regional center of the Lahaina coast with commercial services, civic facilities and spaces, and residential neighborhoods.

Much of the commercial areas of Lahaina Town are included in the Lahaina Historic District which is listed on the National Register of Historic Sites (Figure B-5).

PROBLEM AND OPPORTUNITY IDENTIFICATION

Flooding is the main problem in the Lahaina Watershed. During intense rain storms, flood water and sediment cause damage to homes, businesses, streets, and park facilities. Sugarcane fields, roads, and irrigation systems are also damaged by flooding in the agricultural area. Average annual flood damage amounts to $585,300 for urban properties, $4,200 for public property and emergency services, and $10,700 for agriculture. An average of $71,500 is spent annually to elevate new construction above the 100-year flood level. (Table A - Problems and Opportunities)

Sediment-laden storm runoff turns the nearshore ocean waters a reddish-brown color resulting in income losses for ocean-front hotels and ocean-based businesses, reduced recreational opportunities, and reduced visitor appeal of the Lahaina area. Average annual income losses due to "red water" have been estimated to be $107,900. Sedimentation and uncontrolled runoff are recognized as a threat to the ecology of nearshore coral reef.

Flood Damage

Flooding in the Lahaina area usually occurs during intense storms which bring heavy rains of short duration. Over 25 damaging floods have been recorded in the Lahaina area since 1879.

The greatest flood of record occured in May 1960, when up to 21.7 inches of rain fell in one day on the upper Kahoma basin. Thirty-six homes and a pineapple cannery in Lahaina were flooded. Front Street and Honoapiilani Highway were overtopped by floodwaters and made impassable. Streets and yards were covered with silt. Agricultural damage included extensive field erosion and damage to the irrigation system. Rock masonry channel walls

were damaged. Total damage for this flood amounted to $320,000 in 1960. The Corps of Engineers estimated that a flood of similar magnitude occurring in 1974 would have caused an estimated $1.48 million in damage. Without adjusting for land use changes and increased development since 1974, the damage caused by such a storm in 1990 would be $2.5 million.

Flood damage analyses conducted for this plan indicate that floodwater losses inflicted by a 100-year storm would be approximately $5 million dollars in 1990.

The U. S. Army Corps of Engineers' Kahoma Stream Flood Control Project addresses the flooding problems in the section of Lahaina town north of Lahainaluna Road. The Kahoma Stream drainage basin include two major valleys, Kahoma and Kanaha, located north of the Lahaina watershed. The Kahoma Stream project will install structural measures including a debris basin and a concrete channel to provide flood protection to the north end of Lahaina Town. These measures are currently under construction.

The Lahaina Watershed project will alleviate the flooding problems in the section of Lahaina town south of Lahainaluna Road.

TABLE A - PROBLEMS AND OPPORTUNITIES
Lahaina Watershed, Hawaii

Problems and Opportunities	Effects
Flood Damage	Floodwater and sediment damage to residential and commercial structures and contents are estimated to be $585,300 on an average annual basis.
	Lahaina Historic District is flooded.
	Floodproofing will be required for all new buildings. Estimated average annual cost is $71,500.
	Street surfaces are damaged and sediment and debris cleanup is required for streets and drainage systems. Damage and cleanup costs are estimated to be $4,200 on an average annual basis.
	Inundation of roadways result in road closures and traffic disruption.
	Access to emergency services is hampered.
	Human health and safety are threatened.
	Floodwater and sediment damage to sugarcane crops, fields, roads, irrigation systems, and ditches is estimated to be $10,700 on an average annual basis.
Sedimentation of nearshore ocean waters	An average of 4,550 tons of sediment enters the ocean yearly, 3,400 tons fronting Lahaina town and 1,150 at Kauaula Stream.
	Income losses for ocean-front hotels is estimated to be $107,900 on an average annual basis.
	Ocean recreational opportunities are reduced.
	Visitor appeal of Lahaina is reduced.
	Coral reef ecosystems are damaged.

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The flood problem begins in the sugarcane fields above Lahaina Town where excess runoff flows through fields and down canefield roads washing out young cane, eroding fields and roads, and damaging irrigation systems and storm ditches. In-field terraces have been constructed to divert flows to adjacent drainages. Concrete-lined irrigation and storm ditches running along the contour also divert some of the runoff to Kauaula Stream. However, the terraces and ditches are designed to handle frequently recurring storm events. Runoff generated by storms of 2 to 5-year recurrence overtops the ditches.

Runoff ponds along the upslope shoulder of Honoapiilani Highway and overtops the highway when highway culverts reach capacity or become plugged with debris. The runoff flows through the town, ponding in low spots and flooding roads, residences, businesses, and public properties. Locally generated runoff also contributes to the problem. The following areas in Lahaina are prone to flooding: Maluuluolele Park, Front Street, and Wainee Street.

Approximately 210 acres of land in the watershed are located within the 100-year floodplain. Under present conditions, this includes about 80 acres of agricultural land on both sides of Kauaula Stream and to the northwest of Wainee Village and approximately 130 acres of urban land. (Figure B-1)

The County of Maui requires all new construction within the floodplain to build the first floor above the 100-year flood water level. Floodproofing is usually accomplished by elevating the building site with fill material. Total floodproofing cost for future development has been estimated at $3.3 million.

There are 168 residences, 152 businesses, two parks, and two schools affected by the 100-year flood. Floods damage road surfaces and require mud and debris removal from streets and drainage systems in Lahaina Town. The average annual urban damage from flooding, including floodproofing and public agency costs, is estimated to be $768,900.

In addition to pavement damage and sediment and debris deposition, past floods have indundated Honoapiilani Highway and roads in Lahaina Town resulting in road closures and traffic disruption and congestion. Inundation of roads in Lahaina Town affects the many businesses which rely on tourist flow brought in by cars or buses from outlying resort areas. Keeping Honoapiilani Highway open to traffic is vital to the economy of the Lahaina District because it is the only thoroughfare to the Kaanapali-Napili resort area.

Road closures also hamper access by emergency services. Police, fire, and medical vehicles can be delayed in responding to calls for assistance, resulting in a threat to human life, health and safety.

Except for the very young and the invalid, the depths and velocities of floodwater in Lahaina Town do not pose a threat to human life. Depths to 1.8 feet with a velocity of 0.3 feet per second can be expected on Front Street during the 100-year flood. A threat to human safety can exist in the floodplain adjacent to the Kauaula Stream outlet due to the high volume of discharge from the subwatershed. Depths of 1.5 feet flowing at two feet per second can be expected in the Puamana Subdivision during the 100-year flood.

In the agricultural area, 80 acres of sugarcane land are susceptible to flooding during a 100-year event. Total damage to crops, fields, roads, irrigation systems, and ditches has been estimated to be $50,000 for a 100-year event and $10,700 on an average annual basis.

Sedimentation

The estimated gross erosion rate on the sugarcane fields located in the watershed is 9.6 tons per acre per year. Only a fraction of the gross erosion amount is actually transported off of the sugarcane fields as most of the sediment is redeposited in the fields. The quantity of sediment that is transported downstream is called sediment yield. The estimated sediment yield from the Kauaula subwatershed is 1,150 tons per year and 3,800 tons per year from the Lahaina subwatershed, for a total of 4,950 tons per year for the watershed. Four hundred tons of sediment from the Lahaina subwatershed is trapped by roadside swales or settles in the low areas in Lahaina Town.

It is estimated that an average of 4,550 tons of sediment are carried by storm runoff to the ocean annually. Approximately 3,400 tons of sediment from the Lahaina subwatershed enter the area within the fringing reef fronting Lahaina Town. The nearshore ocean waters turn a reddish-brown color for several days following a storm.

Clear ocean water is an important element of the overall visitor appeal of the Lahaina area. "Red water" reduces visitor appeal which, in turn, negatively affects the tourist industry.

There are two ocean-front hotels in Lahaina Town with a total of 192 rooms. The "red water" diminishes the attractiveness of the hotels in the area and

tourists are prompted to shorten or cancel their stays. Income losses are estimated at $107,900 on average annual basis.

Ocean activity businesses suffer income losses during periods of "red water." The reef area between Lahaina Harbor and the Kauaula Stream outlet is used by snorkelers and scuba divers on charter tours from Lahaina Harbor. The area is also a good location for surfing. Several instructors use it on a daily basis to teach surfing. Glass bottom boat operators regularly ply the waters offshore of Lahaina Town. During "red water" episodes, tourists are less likely to pursue these ocean activities.

The nearshore ocean waters offer many noncommercial recreational opportunities for local residents and tourists. In the area fronting Lahaina Town fishing by shorecasting, gill netting, throw netting, and spear fishing is practiced. Seaweed, octopus, lobster, and live shells are also collected on the nearshore reef. Surfing, kayaking, and windsurfing are other recreational activities practiced in the area. "Red water" limits these recreational activities or makes them less enjoyable. The number of recreation days lost due to "red water" is not known.

Sediment and freshwater discharge can have a harmful effect on reef biota. During floods, runoff from the Lahaina watershed enters the ocean at three general areas: along the Front Street seawall between Lahainaluna Road and Dickenson Street, between Maluuluolele Park and Kamehameha III School, and in the vicinity of the Kauaula Stream mouth. The benthic survey conducted during the course of planning indicates the nearshore ecosystem of the first two discharge areas within the fringing reef to be more developed, diverse, and, therefore, more susceptible to harm by sediment and freshwater inundation. The Kauaula Stream mouth is not surrounded by

fringing reef and has less species diversity than the other two areas. The benthic survey concludes that impacts by sediment and freshwater discharge will be less severe at the Kauaula Stream mouth than within the fringing reef area that fronts Lahaina Town. The more vigorous wave climate and ocean current at the stream mouth will dissipate and carry away sediment more effectively than within the fringing reef.

INVENTORY AND FORECASTING

SCOPING OF CONCERNS

A scoping process was used to identify the concerns that might affect the formulation or selection of alternatives and the resources that may be affected by project actions. Meetings were held involving the SCS, Sponsors, other government agencies, and the general public to identify the concerns. Several of the agencies and individuals were contacted directly for information or comment through written requests.

A broad array of environmental, economic, and social concerns were considered. (Table B - Evaluation of Identified Concerns) Each concern was ranked according to its significance to decision making. Concerns ranking "high" have a significant effect on decision making. Those ranked "medium" may be affected by some alternative plans, while those ranked "low" or "none" will not be impacted by any proposed alternatives or will have little significance to decision making.

Alternatives were formulated to reduce flood water and sediment damage to urban and agricultural properties and to reduce sedimentation of nearshore ocean waters. The effects of the proposed alternatives on the significant concerns are included in Table E - Summary and Comparison of Candidate Plans. Factors that will not be significantly impacted by the proposed alternatives are discussed below.

TABLE B - EVALUATION OF IDENTIFIED CONCERNS
Lahaina Watershed, Hawaii

Economic, Social, Environmental, and Cultural Concerns	Degree of Significance to Decisionmaking 1/
Flood water and sediment damage to urban properties	High
Flooding of Lahaina Historic District	High
Cost of floodproofing new buildings	High
Road and street flood damage and cleanup	High
Road closures and traffic disruption and congestion	High
Access to emergency services	High
Threat to human health and safety	High
Reduction in the quality of life	High
Floodwater and sediment damage to agriculture	High
Sediment discharge into nearshore waters	High
Income losses for ocean-front hotels	High
Income losses for ocean-based businesses	High
Ocean recreation opportunity	High
Visitor appeal of Lahaina area	High
Threat to coral reef ecosystem	High
Prime and important farmlands	High
Visual effects	High
Geologic hazards	High
Land use changes	Low
Threatened and endangered species	None
Stream fish habitat	Low
Wildlife habitat	Low
Wetlands	None
Air quality	Low
Mineral resources	None
Agricultural water storage development	Low
Increase ground water recharge	Low

1/ High - Must be considered in the analysis of alternatives.
Medium - May be affected by some alternatives.
Low - Considered, but not too significant.
None - Need not be considered in analysis.

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Land Use Changes - Low

At the present time, land use in the 100-year floodplain consists of 130 acres of urban and 80 acres of agricultural land. According to the Lahaina Community Plan, future land use in the 100-year floodplain will consist of 146 acres of urban and 64 acres of agricultural land. The proposed alternatives will not affect these planned land use changes nor encourage the conversion of agricultural land to urban uses.

The Pioneer Mill Company will lose use of approximately 18 acres of their plantation operation to the flood protection structures. The acreage loss is mitigated by the reduction of sediment from the sugarcane fields washing into the urban area during storms.

Threatened and Endangered Species - None

There are no identified threatened or endangered species of plant or animal within the watershed. The only endemic bird in the area is the Hawaiian owl, or pueo (Asio flammeus sandwichensis). The owl is present in the area because of the likelihood of rats and mice inhabiting the sugarcane fields.

Stream Fish Habitat - Low

The proposed alternatives would affect the lower reaches of Kauaula Stream from a reach 500 feet above Honoapiilani Highway to the ocean. At the present time, most of the lower section of stream is a cement rock masonary channel with a concrete channel bottom which is dry throughout the year except during period of heavy rainfall. The cobble/boulder bed of the unimproved upper reach is also usually dry. Except for the tidal backwater

in the improved outlet channel, no fish habitat exists in the project-affected reaches of Kauaula Stream.

Wildlife Habitat - Low

The lower reaches of the watershed are fully developed for urban uses and offer little or no wildlife habitat. The sugarcane fields are habitat for mongoose, rats, and mice. The proposed alternatives will require approximately 18 acres of sugarcane land and 2.4 acres of undeveloped shrub-covered land for the installation of the floodwater diversion channel. The conversion of the acreage to flood prevention purposes should not significantly affect wildlife populations.

Wetlands - None

No wetlands have been identified within the watershed and no known wetlands would be affected by the proposed alternatives.

Air Quality - Low

There may be an increase in dust during construction of any of the proposed alternatives. The increase in dust will be temporary and localized to the construction area.

Mineral Resources - None

There are no identified mineral resources within the watershed.

Agricultural Water Storage Development - Low

The use of a floodwater detention reservoir as a possible structural measure for flood prevention was investigated in the early planning stages.

Reservoir capacity in excess of flood prevention needs may have provided an opportunity for agricultural water storage. This measure, however, was dropped from consideration because of the lack of a suitable reservoir construction site in or near the watershed.

Increase Groundwater Recharge - Low

The recharge of groundwater resources through the infiltration or injection of flood discharge was suggested. There are no opportunities to increase groundwater recharge via the project.

EXISTING RESOURCES

The following section provides a brief description of the resources, developments, and social conditions existing in the watershed. Interaction of the project with existing resources and conditions will be described.

Floodplain

Approximately 210 acres in the watershed are located within the 100-year floodplain. Approximately 80 acres of agricultural land along Kauaula Stream and above Honoapiilani Highway between Shaw Street and Prison Street are included. The floodplain includes 130 acres of urban land that is situated mostly below Honoapiilani Highway.

The following depths of flooding can be expected in Lahaina Town during a 100-year flood event under future without project conditions: 1.9 feet in the Front Street area and 1.3 feet in the Wainee Street area. Maximum velocities are between 0.9 feet per second and 0.5 feet per second.

Depths of 1.5 feet with velocities up to two feet per second can be expected in the Puamana Subdivision adjacent to Kauaula Stream.

Urban Development

There are 253 single family residences, four condominium buildings, two hotels, 239 business establishments, two schools, and two parks located within the watershed at the present time. Approximately 168 single family residences, 35 condominium units, 152 business establishments, two schools, and two parks are located in the 100-year floodplain.

The County of Maui requires all new construction located within the floodplain to build the first floor above the 100-year flood level. Floodproofing is generally accomplished by elevating or "padding up" the building site with soil or fill material.

Agricultural Production

There are 1,080 acres of land in the watershed used for the production of sugarcane. These acres are part of the Pioneer Mill Company sugar plantation which encompasses 9,000 acres in West Maui. Of the 1,080 acres, 80 acres are located in 100-year floodplain. Pioneer Mill estimates that 10 percent of the land is used for roads, ditches, and other "non-cane" uses. All of the sugarcane fields in the watershed are drip irrigated. Yields average 13.5 tons per acre per year. Approximately one-half of the fields are harvested each year.

The SCS Wailuku Field Office has provided technical assistance to the Pioneer Mill Co. for the installation of soil conservation practices. All of the sugarcane acreage in the watershed are treated. Conservation

practices include 102,900 feet of terraces, 8,000 feet of storm diversions, 49 acres of contour farming, and 982 acres of cross slope farming. All of the fields in the watershed are chiseled and have volunteer cover crop. Current annual soil erosion rates on the sugarcane land average 9.6 tons per acre in the watershed, which means that nearly ten tons of surface soil ares moved through erosional activity but not necessarily off of the field.

Social and Demographic

Lahaina Town is a densely populated urban area. Jobs in the growing service sector outnumber working residents. Employment in agriculture has declined in recent years.

Household income in the Lahaina District is projected to increase from $21,900 in 1980 to $26,700 in the year 2000 (1980 constant dollars). This income level is average for all districts on Maui.

The population is composed of many ethnic backgrounds and income levels. Pioneer Mill workers, retirees, and their families, many of whom have lived in or near the watershed since early this century, are predominantly of Japanese or Filipino ethnic backgrounds. Many have middle class homes in the subdivisions along Lahainaluna Road and in the residential areas below Honoapiilani Hwy. Some workers reside in Wainee Village, a vestigial "plantation camp", likes of which once dotted the West Maui sugarcane fields. The homes and property in Wainee Village are owned by Pioneer Mill and are provided to the workers at nominal cost.

The growth of the Lahaina coast as a resort area has brought an influx of new residents and visitors, primarily from the U. S. mainland and Canada, into the watershed. Condominium and hotel developments such as the Puamana

subdivision, Lahaina Shores, and the Maui Islander have been constructed mainly for this market. Mostly Caucasian, this segment of the community is generally older, more affluent, and better educated than the other major sectors of the population.

A community of service sector workers has also developed. This group includes younger, mobile mainlanders, immigrants from Asia and Pacific Islands, and former sugar company workers and their families. Although wages in the tourism-related service industry are generally low, entreprenurial opportunities are many.

Nearshore Ocean Waters and Reef System

The clear ocean waters and well-developed reef system along the Lahaina coastline offer many recreational opportunities for watershed residents and tourists. Many tourism-based businesses also rely on the ocean and reef system for their operation.

The reef system extends along the coastline bordering Lahaina Town from Kauaula Stream on the southeast to Mala Wharf on the northwest. The only break in the reef is the access channel to Lahaina Harbor.

The Maui Coastal Zone Atlas indicates that fishing by shorecasting and gillnetting is practiced in the nearshore ocean waters near the outlet of Kauaula Stream, or Makila Point. Limu (seaweed) collecting, octopus fishing, and spearfishing occur on the adjacent reef flat. This area is frequently used by snorkelers and scuba divers on commercial tours and by glass-bottom boats out of Lahaina Harbor. During periods of wave activity, the area is a good location for surfing and several instructors use it on a daily basis to teach surfing.

The Atlas also indicates fishing by shorecasters and net-throwers in the nearshore ocean waters just southeast of Lahaina Harbor, with spearfishing offshore. Clark, in The Beaches of Maui County, reports that this area of reef fronting Front Street "is not attractive to most adults as a swimming area. Snorkelers and divers make good use of the area, however, as do many surfers."

An inventory of Maui's coral reefs, published by the Corps of Engineers, documents excellent visibility in deeper waters off Makila Point, with extensive coral cover. These characteristics are important to the diving charter and glass-bottom boats operating out of Lahaina.

FORECASTED CONDITIONS

The resources inventoried in the preceding section could change in the future. Since the evaluation period for this project is 50 years, the condition of these resources was projected into the future, assuming no implementation of a flood protection project, to insure that the alternatives would be suited to long term needs and conditions and to serve as a baseline for evaluating the effects of the alternatives over their expected life.

Urban Development

There is a critical shortage of housing and business/commercial property in the Lahaina area. The Lahaina Community Plan designates 45 acres in the urban areas of Lahaina Town for development to more intensive uses. For example, many current residential areas are zoned for business/commercial use. Sixteen acres presently used for sugarcane production are also

designated to be rezoned for urban uses such as single and multifamily residential and commercial.

Many of the older historic buildings can only be altered within the guidelines for the Lahaina Historic District. These buildings will be maintained and are expected to remain for the 50-year project evaluation period.

Under future conditions, based on the Lahaina Community Plan, there would be 311 single family residences, four condominium buildings, six hotels, three shopping plazas with 350 shops, 306 business establishments, four parks, and two schools located within the watershed. The County of Maui requires all new construction within the floodplain to build the first floor (habitable level) above the 100-year flood water level. All new buildings, therefore, will not be subject to flooding during the 100-year or lesser intensity floods. Under these conditions there will be 168 single family residences, 35 condominium units, 152 business establishments, two schools, and two parks subject to flooding from a 100-year storm.

Agricultural Production

The Lahaina Community Plan designates 16 acres presently used for sugarcane production for conversion to urban uses. This land is located above Honoapiilani Highway and is partially located in the 100-year floodplain. This conversion is expected to occur with or without project installation. The loss of these acres should not effect the productive capability of the Pioneer Mill Company plantation.

Social and Demographic

The Lahaina Community Plan recommends diversification of the economic base to include agriculture, visitor industry, light industrial, and commercial and professional services. The Community Plan recognizes the importance of agricultural activity to the social character of the area. The viabilty of agriculture and the preservation of the land resource base for agricultural activities have been designated as "highest" priority issues.

A policy of slow population growth has been recommended by the Lahaina Community Plan. A resident population of 20,000 in the greater Lahaina area is envisioned in the year 2001. Although infill in Lahaina Town is expected in the near term, most of the population growth is expected to take place outside of the Lahaina Watershed. The Community Plan also recommends retention of the small-scale, rural character of the region.

FORMULATION OF ALTERNATIVES

Alternative plans were formulated to address the problems and concerns described earlier in the Problems and Opportunities and the Inventory and Forecasting sections. The alternatives gave full consideration to current local, state, and federal guidelines and policies and to the concerns expressed by community interests. The basic requirement of all alternatives is that they be economically feasible, socially and environmentally acceptable, and effective in solving the identified problems.

FORMULATION PROCESS

The formulation of alternative plans was accomplished in three phases. The first phase consisted of developing measures to solve the water resource problems identified through the scoping process described earlier. Solutions to the problems were formulated taking into account the resource capabilities of the watershed, public concerns, and forecasted changes or conditions in the project area. Land treatment, nonstructural, and structural measures were considered. Each measure was evaluated in terms of its effectiveness in solving the flooding problems in an economically and environmentally acceptable manner.

The second phase of formulation consisted of developing alternative plans. Those measures that remained viable after the evaluation during the first phase were analyzed in detail and were refined into alternative plans. The benefits, costs, and environmental effects of the alternatives were evaluated. The alternatives were tested for completeness, effectiveness, economic feasibility, and acceptability.

Those alternatives that remained after this screening were further refined to maximize beneficial effects through an incremental analysis process. These alternatives were designated as candidate plans. A National Economic Development (NED) plan which maximizes the net economic benefit conferred by the project was developed as a candidate plan. A No Action plan is also included for the sponsors to consider as a candidate plan.

The third phase consisted of comparing the candidate plans and establishing a rationale for the selection of the recommended plan.

MEASURES

The following structural and nonstructural measures were considered during the formulation of alternative plans.

Land Treatment Practices

Land treatment practices are vegetative or cultivation practices designed to reduce runoff and erosion potential in the watershed. The Pioneer Mill Company, with SCS technical assistance, has installed land treatment practices to control runoff and limit erosion on its sugarcane lands. All of the sugarcane fields in the watershed have SCS planned land treatment measures installed. The practices are effective up to 10-year frequency storms. More intensive land treatment in the upper watershed could reduce sediment discharge. However, land treatment would not appreciably diminish the flooding problem due to the steep watershed topography.

Nonstructural Measures

The nonstructural measures that were considered are intended to modify the impacts of flooding rather than modifying the flood itself. The nonstructural measures that were considered are discussed below.

Zoning of the floodplain to restrict its further development was examined, but was considered impractical. One reason is that zoning regulations would not prevent damage to existing development. Another is public resistance to development restrictions in Lahaina Town, the primary commercial district of West Maui.

Acquisition of vacant parcels and the removal of flood prone buildings was considered but was thought to be too costly. Ocean front properties in the floodplain area have sold recently for as much as $430 per square foot.

Relocation of existing floodplain properties to areas outside the floodplain was considered and found to be cost prohibitive.

Floodproofing of flood-prone buildings was investigated. This included elevating structures, building perimeter walls around properties, building protective walls around structures, and applying sealants. The density of development in Lahaina Town and the age of many of the structures makes the installation of floodproofing measures difficult. Historic building guidelines may restrict the application of floodproofing methods on many structures in the Lahaina Historic Preservation District. The lack of an adequate flood warning period also limits the practicality of floodproofing measures that require the placement of flood shields and seals following the sounding of a flood warning.

A system of flood forecasting, warning, and evacuation was considered to be ineffective in the Lahaina area due to the flashy nature of the flooding in the watershed.

Structural Measures

Structural measures require group action for installation, provide protection to more than one structure or landowner, and are operated and maintained by the Sponsors. The structural measures considered for flood control included detention reservoirs and flood channels. The structural measures considered to reduce sedimentation included sediment and debris basins.

A cursory search was made for a detention reservoir site in the Kauaula and Lahaina subwatersheds. No adequate sites were found and the detention reservoir measure was dropped from further consideration.

The flooding in Lahaina Town is a result of runoff conveyed through numerous small drainages spread along the width of the Lahaina subwatershed. For this reason a diversion channel to intercept the runoff from the Lahaina subwatershed and carry it to a safe outlet appeared to be the most practical solution to the flooding problem.

The basic diversion channel that was considered extended across the Lahaina subwatershed from Lahainaluna Road to Kauaula Stream. Differing channel sizes to contain various levels of storm runoff or provide various levels of flood protection were studied. The main segment of the diversion channel was designed as a vegetated earth channel to minimize installation costs. A concrete channel was required for the upstream reach of the diversion because of the steep slope along Lahainaluna Road. The diversion

channel was set below the general slope break at the 50 foot to 80 foot elevation to minimize the volume of excavation and embankment fill. The diversion channel was designed with a grade of .0035 to .0040 to minimize the right of way needs while maintaining vegetated earth channel stability.

The alignment of the diversion channel was constrained by topography, proposed development plans, and existing features.

A low diversion alongside Honoapiilani Highway was considered as an alternative which minimized the amount of agricultural land needed for implementation. However, residential development plans by AMFAC, Inc. for the area and the unavailability of efficient channel grade forced the diversion alignment upslope into the agricultural area.

The highest alignment below the slope break was selected to provide flood protection to the residential development proposed above Honoapiilani Highway. The channel alignment is constrained by Wainee Village and Pioneer Mill Company's Wainee Reservoir. The channel has been kept below the toe of the reservoir embankment while minimizing its effect on the existing households in Wainee Village. Five houses in Wainee Village may need to be removed for installation of the diversion.

The selected diversion alignment will require the conversion of "prime" and "other important" agricultural land to flood control. However, the diversion alignment overlays 2,000 feet of existing field road and irrigation ditch. Other portions of the works of improvement will be installed in existing drainageways and peripheral areas that are not cultivated but lie within the agriculturally important zones. Cultivated

land that will be converted to project use is estimated to be one-half to two-thirds of the total agricultural land required.

Several outlets for the diversion channel were considered. Outlets considered include Kahoma Stream, a box culvert under Dickenson Street, a culvert through Maluuluolele Park, and Kauaula Stream. The commencement of construction of the Corps of Engineer's flood control project on Kahoma Stream precluded its use to outlet additional runoff from the Lahaina subwatershed. The high construction costs of a 1,500 foot long covered box culvert under Dickenson Street made such an alternative economically infeasible. An analysis of of outletting storm discharge at the remaining two locations was conducted.

A benthic survey of coastal marine life was conducted to evaluate the potential ecological impact of floodwater runoff on nearshore coral reef ecosystems at the two alternative discharge sites, Site A near Maluuluolele Park and Site B at the Kauaula Stream mouth.

The Kauaula Stream outlet (Site B) was recommended over the Maluuluolele Park outlet (Site A) for the following reasons:

1) The reef at Site B has less relief and more sediment cover than Site A.

2) Site B has fewer species of algae and coral and less percent coverage of living coral. Flow from Kauaula Stream has produced a marine community better adapted to sediment and freshwater discharge.

3) Coral ecosystems at Site B were judged to have been more impacted by sediment than Site A.

4) Increases in sediment discharge due to large storms would be expected to produce less relative increase in mortality to coral at Site B than Site A.

5) Site B has fewer recreational uses than Site A.

A supplemental study to evaluate the effects of splitting the flow of Kauaula Stream and diverting a portion of the flow south to a secondary outlet was also conducted. The study was prompted by concerns over potential increases in sediment discharge and runoff at Kauaula Stream from the Lahaina subwatershed. An equally important consideration was to minimize the disruption that would be caused by the reconstruction of two bridges and the Kauaula outlet channel to accommodate a 100-year storm discharge.

The supplemental marine study concluded that the optimum location for the secondary outlet from a marine ecology viewpoint would be 3,600 feet south of Kauaula Stream. The study also concluded that the optimum design would divide the 100-year discharge so that 60 percent of the flow would discharge via Kauaula Stream while 40 percent of the discharge is diverted to the second outlet.

Concerns about the effects of sedimentation on the nearshore ocean waters prompted the use of sediment basins along the diversion channel to reduce the fine sediment load entering Kauaula Stream. Sediment yields on an average annual and storm frequency bases were established and the sediment

basins were designed to provide sufficient sediment trapping capability and capacity.

There were also concerns regarding the damaging effects of boulders and cobbles in the proposed Kauaula Stream concrete outlet channel. A debris basin on Kauaula Stream was incorporated in the plans to keep boulders and cobbles from entering the improved outlet channel.

Four structural flood protection combinations were developed using the feasible measures identified above. A common feature is a diversion channel that starts at Lahainaluna Road, extends across the watershed, and outlets into Kauaula Stream. Three proposals were developed that outlet all of the controlled storm discharge through Kauaula Stream. The three were differentiated by level of protection and by their proposed modifications of the existing Kauaula channel. The fourth structural combination includes a secondary outlet that would split the flow of Kauaula Stream and divert a portion of the flow south. A No Action proposal was also considered.

Although there are dimensional differences for the diversion channels across the Lahaina subwatershed due to varying levels of protection, the alternatives share the same centerline alignment of the channel from Lahainaluna Road to Kauaula Stream. The following improvements are proposed between Sta. 96+70, at Lahainaluna Road and Sta. 9+80, which is just upstream of the highway and cane road bridges at Kauaula Stream (Figure G):

- inlet basin alongside Lahainaluna Road,
- approximately 1,024 feet of rectangular reinforced concrete channel with an energy dissipating basin,

- 5,800 feet of earth diversion channel with three sediment basins,
- a debris basin with a 130-foot long reinforced concrete outlet channel at Kauaula Stream,
- and relocation of four cane road crossings and four pipelines.

The first configuration would provide flood protection from storms not exceeding the 100-year recurrence interval. Supplemental discharge capacity for the Kauaula Stream outlet channel would be provided by constructing additional bridges under the cane haul road and Honoapiilani Highway alongside the two existing bridges. The outlet from the debris basin would incorporate a splitter to proportion the discharge to the two bridge pairs. The existing Kauaula Stream cement rock masonary outlet channel will be replaced with a rectangular reinforced concrete channel. The installation cost for this configuration is estimated to be $6,608,400.

The second configuration was designed to provide flood protection from storms not exceeding the 50-year recurrence interval. The level of protection afforded by this alternative is limited to the capacity of the existing cane road and Honoapiilani Highway bridges on Kauaula Stream. In addition to the installation of the diversion channel and debris basin this alternative proposes replacement of the concrete-rock-masonry outlet channel with a rectangular reinforced concrete channel. The existing bridges at Honoapiilani Highway, the cane haul road, and Front Street will be retained. The installation cost of this configuration is $5,815,600.

The level of protection of the third alternative configuration is limited to the capacity of the existing Kauaula Stream cement rock masonary channel. This configuration would provide flood protection from storms not exceeding the 27-year recurrence interval. Other than the debris basin,

this alternative initally proposed no modification of the existing outlet channel on Kauaula Stream. Later evaluation indicated that increased flow velocities due to upstream improvements warranted a reinforced concrete channel to assure sidewall stability. The installation cost for this configuration is estimated to be $5,359,000.

The fourth configuration was developed to avoid reconstruction of the outlet channel and three bridges downstream of the proposed debris basin while providing a 100-year level of protection. A second outlet channel from the debris basin will be constructed to accomodate discharge in excess of the existing outlet capacity. Additional improvements include 3,500 feet of earth channel to be constructed to the south of the debris basin and a reinforced concrete culvert and outfall under Honoapiilani Highway. The installation cost of this configuration is estimated to be $6,400,600. As the effects of this configuration are not substantially different from the first alternative configuration, above, the lower cost configuration was used in the incremental benefit:cost analysis to identify the National Economic Development (NED) plan.

ALTERNATIVES

Evaluation of Alternative Plans

The alternatives were evaluated and developed to the extent necessary to determine costs, benefits, and effects on environmental resources. The advantages, disadvantages, risks, and uncertainty of each plan were considered.

The general viability of each alternative was determined by considering four aspects:

Completeness - The extent to which an alternative accounts for all investments and actions necessary to realize planned results.

Effectiveness - The extent to which an alternative alleviates the problems and achieves the opportunities identified.

Efficiency - The extent to which an alternative is most cost effective.

Acceptability - The extent to which an alternative is accepted by the public and compatible with existing laws, regulations, and policies.

ALTERNATIVE 1 - No Action

This alternative foregoes project implementation and is basically a continuation of present conditions. The flood and sediment problems will continue unabated.

ALTERNATIVE 2 - National Economic Development Plan

This structural alternative is based on the combination of measures that optimize the National Economic Development Account. The Economic and Environmental Principles and Guidelines for Planning Water and Related Land Resources Implementation Studies requires the formulation of a National Economic Development (NED) plan. By definition, the NED plan maximizes the net remaining benefits attributable to the project measures.

Three alternative configurations, described as one, two, and three earlier, were considered. Each configuration was developed to the degree needed to

estimate costs and effects. The three alternative configurations essentially have the same types of effects on flood and sediment reduction. The three are compared in the NED analysis to determine the level of protection at which the net benefit is maximized.

EVALUATION OF BENEFITS

The evaluation of benefits for the Lahaina Watershed Project measures the beneficial contributions to national economic development associated with flood hazard and sediment damage reduction . The project improvements contribute to the NED objective by improving the net productivity of flood-prone land resources. This occurs either by an increase in output of goods and services and/or by reducing the cost of using the land resources. Evaluated conditions include potential land use changes, additional development, and similar modifications which will alter the hydrologic response and potential economic damages. The benefit analysis involves analyzing the relationship between hydrologic, hydraulic, and economic characteristics of the floodplain in accordance with standard SCS procedures. Procedures are in accordance with The Economics and Environmental Principles and Guidelines for Water and Related Land Resources Studies issued by the Water Resources Council on March 10, 1983.

The principal benefits for flood control facilities are inundation reduction benefits. These "benefits" are the loss in income to the nation as a result of flooding, commonly measured as physical damage, business losses, and emergency costs. The inundation reduction benefit is the value of reducing flood losses to activities in the floodplain. It is measured as the reduction in the amount of damages or related costs.

The economic life of the project or project evaluation period will be 50 years. This period is consistent with projects of this scope and type. The discount rate for Fiscal Year 1990 Federal water resources projects is 8-7/8 percent. All benefits and costs are evaluated in constant 1990 dollars.

The benefits of flood hazard reduction were determined by comparing the estimated average annual flood damages with and without the project. Average annual flood damage was derived by adding the projected damage from all of the floods expected during a 100 year period and dividing the total by one hundred. The average annual flood damage analysis includes the damage to agricultural and urban development in the floodplain, public agency and emergency costs, floodproofing costs for new construction, and economic loss due to "red water." Data used in the evaluation of flood damages and benefits were obtained from field investigations of agricultural, residential, commercial, and public properties. For the evaluation, commercial and residential benefits were derived for three areas: Lahaina subwatershed-North, Lahaina subwatershed-South, and Kauaula subwatershed.

The average annual costs and benefits for the 27-year, 50-year, and 100-year level of protection plans are shown on Table D - Incremental Analysis of NED Plan. The preliminary benefit-to-cost ratio for the 27-year, 50-year, and 100-year plans are 1.11:1.00, 1.17:1.00, and 1.09:1.00, respectively.

TABLE D - INCREMENTAL ANALYSIS OF NED PLAN
Lahaina Watershed, Hawaii
(Dollars)

Description of Increment	Annual Costs		Annual Benefits		
	Incremental Cost	Total Cost	Incremental Benefit	Total Benefit	Net Benefits
27-year Protection	518,900	518,900	578,500	578,500	59,600
50-year Protection	50,100	569,000	91,200	669,800	100,800
100-year Protection	74,800	643,800	36,000	705,800	62,000

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By virtue of high net benefits and benefit-to-cost ratio, the 50-year level of protection alternative was determined to be the National Economic Development (NED) plan.

For the 50-year level of protection, the average annual benefits from reduction of flood damages to residential, commercial, agricultural, and public facilities,reduction in future floodproofing costs, and the reduction in loss of income due to "red water" totals $683,800. Storms with intensities in excess of the 50-year storm will continue to cause economic loss, although at a reduced level. After installation of the project measures, a residual average annual loss of $135,500 due to flooding will continue. The annualized benefits from the proposed project are shown, in detail, in Table 5. A comparative analysis of annualized costs and benefits is included as Table 6.

CANDIDATE PLANS

Candidate plans are those alternatives that could be considered for the recommended plan. Alternative 1 - No Action is a viable choice for the

sponsors and is considered a candidate plan. The NED plan, Alternative 2 above, is also a candidate plan. Table E - Summary and Comparison of Candidate Plans provides a comparison of these plans.

Four accounts are used to record the effects and to facilitate the comparison of the candidate plans. The NED account shows effects on the national economy. The environmental quality (EQ) account shows effects on ecological, cultural, and aesthetic attributes of significant natural and cultural resources that cannot be readily be measured in monetary terms. The regional economic development (RED) account shows the regional impacts of NED effects, income transfers, and employment effects. The other social effects (OSE) account shows urban and community impacts and effects on life, health, and safety. Those concerns having high degree of significance to the decisionmaking process, as shown in Table B - Evaluation of Identified Concerns, are addressed in one of the four accounts.

TABLE E - SUMMARY AND COMPARISON OF CANDIDATE PLANS
Lahaina Watershed, Hawaii

PROJECT FEATURES AND EFFECTS	NO ACTION	ALTERNATIVE 2 50-Year Protection
MEASURES		
Structural Elements	None	Inlet Basin 1,024' Reinforced Concrete Channel 5,800' Earth Diversion Debris Basin with Outlet Concrete Lining for Kauaula Stream
Landrights Elements	None	20.4 Acres Right-Of-Way Four Cane Road Crossings Relocate Four Pipelines
Relocations	None	Five Households
EFFECTS ON URBAN FLOODING		
Floodwater and Sediment Damage to Structures and Contents	Will continue at average annual loss of $585,300.	Reduced by $535,400 on an average annual basis.
Cost to Floodproof New Construction	Will continue to be required at a cost of $71,500 yearly.	Reduced by $51,700 on an average annual basis.
Damage to Streets and Cost of Sediment Cleanup	Will continue to occur with average annual cost of $4,200.	Reduced by $3,800 on an average annual basis.
EFFECTS ON AGRICULTURAL FLOODING		
Floodwater and Sediment Damage to Crops, Roads, Irrigation Systems, and Ditches	Will continue at an average annual loss of $10,700.	Reduced by $9,600 on an average annual basis.
EFFECTS ON "RED WATER" LOSSES		
Income Losses for Ocean-front Hotels	Will continue to occur with $107,900 average annual loss.	Reduced by $69,200 on an average annual basis.
Loss of Venue for some Ocean-oriented Businesses	Will continue to occur.	Incidence reduced.
PROJECT INVESTMENT		
Installation Cost	$0	$5,815,600

TABLE E - SUMMARY AND COMPARISON OF CANDIDATE PLANS
Lahaina Watershed, Hawaii

PROJECT FEATURES AND EFFECTS	NO ACTION	ALTERNATIVE 2 50-Year Protection
NATIONAL ECONOMIC DEVELOPMENT ACCOUNT		
Beneficial, Annualized		$563,100
Adverse, Annualized		$475,500
Net Benefits		$87,600
Benefit:Cost Ratio		1.18 : 1.0
ENVIRONMENTAL QUALITY ACCOUNT		
Sediment Discharge to Nearshore Reef Fronting Lahaina Town	Will continue at an average annual rate of 3,400 tons.	Reduced by an average of 3,370 tons yearly.
Sediment Discharge at Kauaula Stream	Will continue at an average annual rate of 1,150 tons.	Increased by an average of 1,680 tons per year.
Flood Protection of Lahaina Historic District	Will continue to flood.	50-year level of flood protection provided.
Prime and Other Important Farmland	No effect	18 acres required for structural measures
OTHER SOCIAL EFFECTS ACCOUNT		
Transportation	Highway and streets will continue to be flooded.	Reduction in road closures and traffic disruption.
Emergency Services	Access by emergency services will continue to be hampered.	Access by emergency services will be improved.
Human Health, Safety, and Quality of Life	Continued presence of flood hazard	Flood hazard reduced.
Other Social Effects	No effect	Relocation of five households.
Ocean Recreation Opportunity	Opportunities denied by "red water" following storms	Incidence of "red water" reduced recreational opportunities increased
Visitor Appeal	Reduced appeal due to flooding and "red water"	Increased visitor appeal
Geologic Hazard	No effect	Increased hazards due to basin and diversion embankments
Visual Resources	No effect	Structural improvements will be visible from Honoapiilani Hwy. and benefitted area.

TABLE E - SUMMARY AND COMPARISON OF CANDIDATE PLANS
Lahaina Watershed, Hawaii

PROJECT FEATURES AND EFFECTS	NO ACTION	ALTERNATIVE 2 50-Year Protection
REGIONAL ECONOMIC DEVELOPMENT ACCOUNT		
Positive, Annualized		
Region		$563,100
Rest of Nation		$0
Negative, Annualized		
Region		$119,400
Rest of Nation		$356,100

Notes: Interest Rate - All alternatives evaluated at 8-7/8 percent interest.
Period of Analysis - All alternatives evaluated over 50 years.
Price Levels - 1990 price levels used.

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PROJECT INTERACTION

Significant interactions between the candidate plans and existing or expected projects include the following:

1. The U. S. Army Corps of Engineers' Kahoma Stream Flood Control Project is in construction. The project will alleviate flooding in the watershed to the north of Lahaina Watershed and in the floodplain common to both projects at the lower end of Lahainaluna Road.

2. Realignment of Honoapiilani Hwy. between Kauaula Stream and Honokowai is being planned by the Hawaii State Department of Transportation (DOT). Coordination between the State DOT and SCS is being conducted to assure compatibility of the plans.

3. AMFAC Properties, Inc. plans residential and public facilities development in the area to the west of the diversion alignments of the candidate plans. The planned flood prevention measures are formulated to be least disruptive to AMFAC Properties' development plan.

RISK AND UNCERTAINTY

Throughout the planning process efforts were made to obtain the best available data in order to reduce risk and uncertainty. The major areas of risk and uncertainty are discussed below.

1. Storm characteristics such as intensity, duration, and runoff quantities for the various storm frequencies were estimated from limited records for the Lahaina watershed.

2. Sediment yield estimates for the Lahaina subwatershed and Kauaula Stream were made based on known sediment discharges for other Hawaiian drainages and on generalized sediment discharge relationships. Although the correlation between the results of several methods that were used was high for both subwatersheds, sediment yield forecasting is an estimation of an order of magnitude, at best. If the sediment discharge is underestimated, sediment removal from the basins will need to be performed more frequently than anticipated and sediment discharge at the outlet will be higher than expected.

3. Storm runoff and sediment yield quantities for the Lahaina subwatershed were computed with the assumption that the current sugarcane cropping pattern would continue. Should sugarcane cultivation cease or the manner of cultivation or field layout be changed, the runoff rate and sediment yield could increase or decrease.

4. The five households that have been identified for relocation are in Wainee Village, a Pioneer Mill "plantation camp." Wainee Village is being phased out by Pioneer Mill. A voluntary relocation program has been offered to the remaining residents. No new households will be established. If households along the diversion alignment voluntarily move before the start of construction, project costs will be reduced.

5. The channel alignment assumes the continued utilization of the Wainee Reservoir. If the reservoir's use is discontinued other alignments may be available that may decrease the construction cost. Use of the abandoned reservoir as a sediment basin is also possible.

6. Land use in the floodplain under future conditions is based on the Lahaina Community Plan. It is assumed that future land use will not differ with or without the project installed.

7. The estimate of damages and benefits for buildings and their contents was based on the following assumptions: 1) all new buildings in the floodplain will be floodproofed and not susceptible to flooding under future without project conditions, 2) under with project conditions floodproofing costs will be eliminated or reduced, 3) current damage estimates will be used for non-floodproofed (existing) buildings and their contents. No attempt was made to increase the value of residential contents in the future.

RATIONALE FOR PLAN SELECTION

Alternative 2, the NED plan, was selected as the Recommended Plan by the Sponsors. Alternative 2 was also chosen by the majority of attendees at the July 2, 1986 public meeting. It will provide 50-year level of flood protection to the Lahaina Town area thereby satisfying the national and Sponsors' objective of reducing flood losses. It also produces the most favorable benefit:cost ratio and the highest level of net benefits. There are no unresolved conflicts or objections to the selection of Alternative 2 as the Recommended Plan.

RECOMMENDED PLAN

PURPOSE AND SUMMARY

Alternative 2, the National Economic Development plan, is the Recommended Plan. The structural measures proposed by the Recommended Plan will reduce floodwater and sediment damages to agricultural and urban properties and also reduce sedimentation of fringing reef areas.

The Recommended Plan was developed to meet the national and Sponsors' objectives of reducing or preventing floodwater damages. The structural measures included in the plan will be installed under authority of Public Law 83-566 with the purpose of flood prevention. Land treatment measures to reduce erosion and sediment delivery in the upper sugarcane fields will continue to be installed through the ongoing conservation program.

This section of the Plan-EA provides a detailed description of the proposed structural measures to be installed including financing, installation scheduling, and operation and maintenance requirements.

PLAN ELEMENTS

The Recommended Plan proposes the construction of a floodwater diversion channel that starts at Lahainaluna Road, extends across the watershed and outlets into Kauaula Stream. (Figure G - Works of Improvement) The upstream reach of the diversion will be concrete and the lower reach earth. The plan also includes the construction of an inlet basin, an energy dissipating basin, three sediment basins, a debris basin with an outlet channel at Kauaula Stream, and replacing the concrete-rock-masonry channel with a reinforced concrete channel. All bare earth areas including all

diversion surfaces will be vegetated. Following is a brief description of each plan element starting from the upstream end of the improvements.

Lahainaluna Road Inlet Basin

The inlet basin into the reinforced concrete channel section of the proposed diversion will be constructed alongside Lahainaluna Road. The 150-foot by 50-foot basin will be partially excavated and partially embanked with loose rock riprap armoring the entrance. Flows from the drainageway along the south side of Lahainaluna Road and flows from the 18-inch diameter culvert from the subdivision on the north side of the road will be routed into the basin. Boulders and cobbles will be trapped by the basin. Approximately 0.43 acres of right of way will be required for the basin.

Concrete Channel

The concrete channel reach will be an eight foot wide, six to ten foot high, 1024-foot long rectangular reinforced concrete channel, constructed at a four percent gradient between Lahainaluna Road and the earth diversion channel section. Flows will enter from the inlet basin over a 24-foot long side inlet weir. An 85-foot long SAF energy dissipating basin will be constructed at the downstream end of the channel. One sugarcane field road will be rerouted and one field bridge will be installed. Approximately 0.97 acres of right of way will be required.

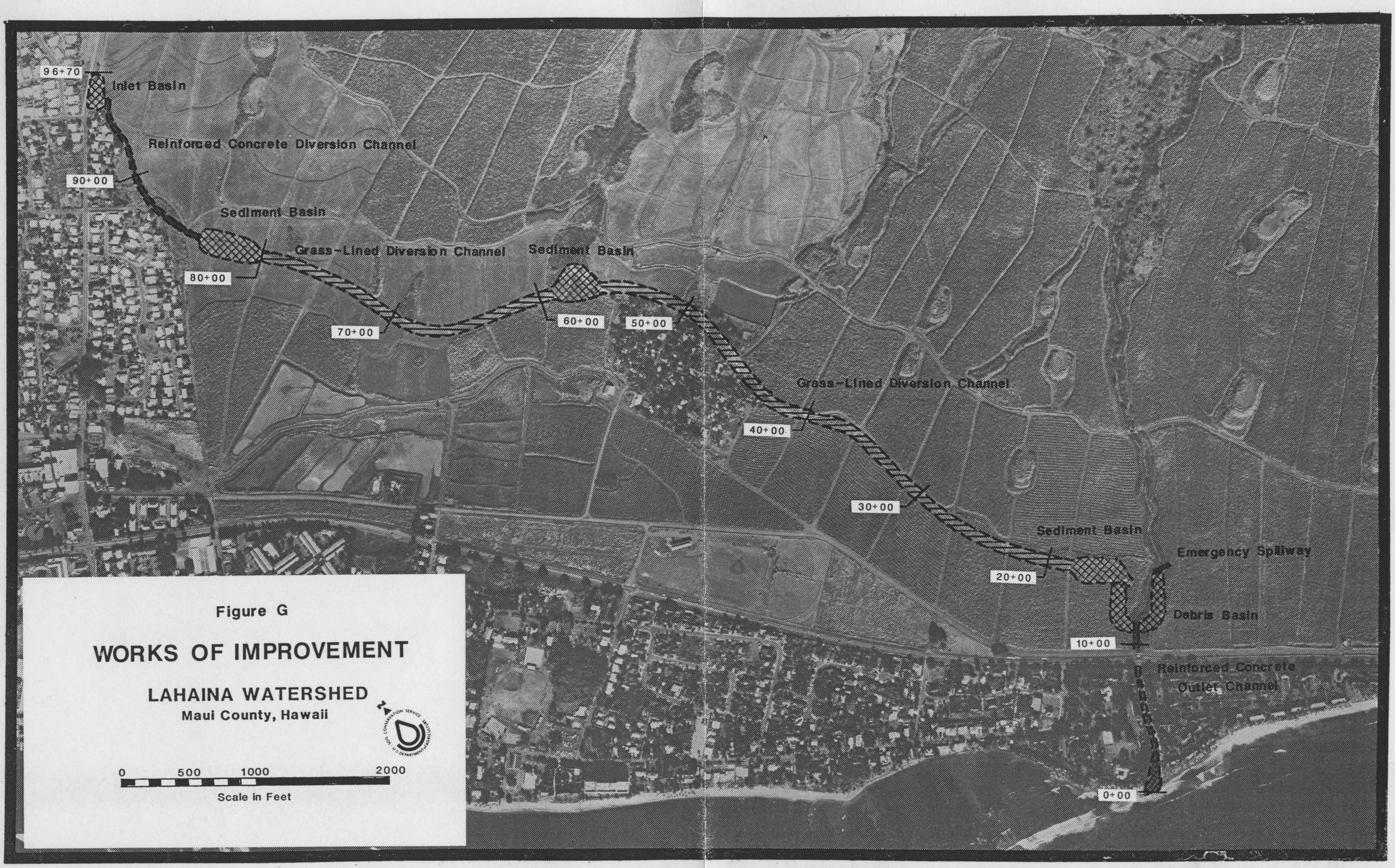


Figure G

WORKS OF IMPROVEMENT

LAHAINA WATERSHED

Maui County, Hawaii

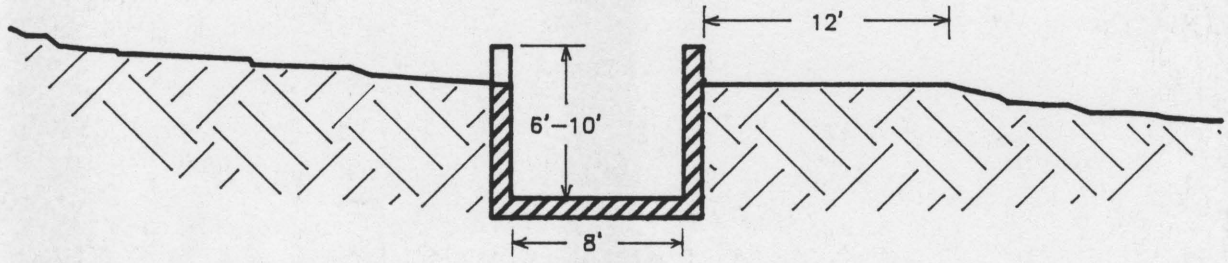
0 500 1000 2000

Scale in Feet

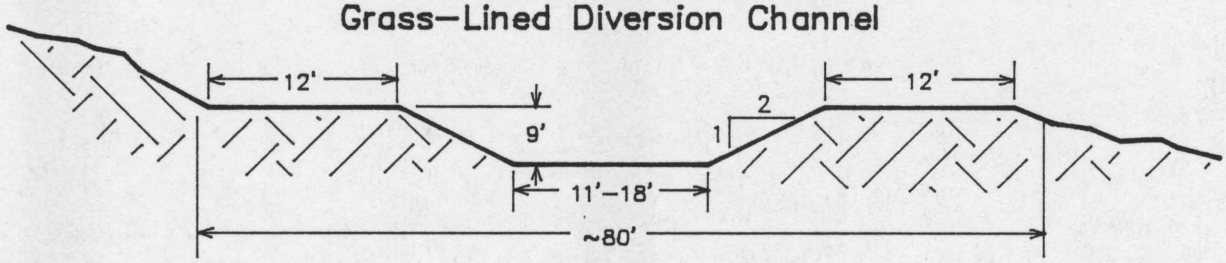
Typical Cross Sections

Not to Scale

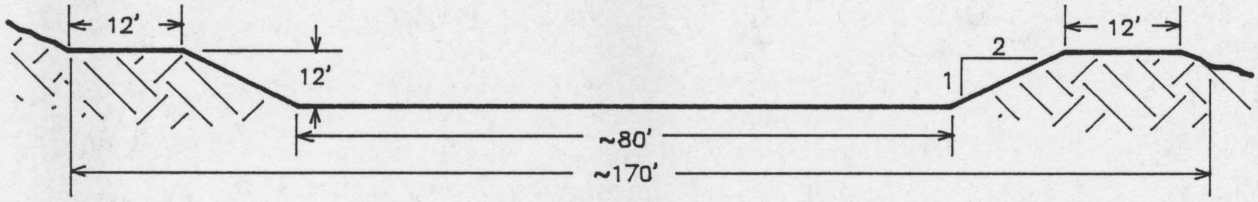
Reinforced Concrete Diversion Channel



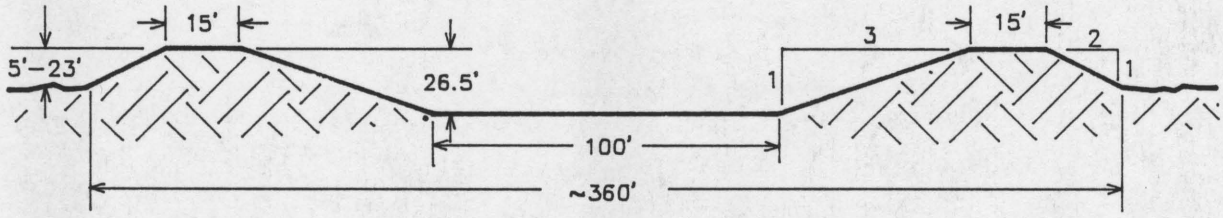
Grass–Lined Diversion Channel



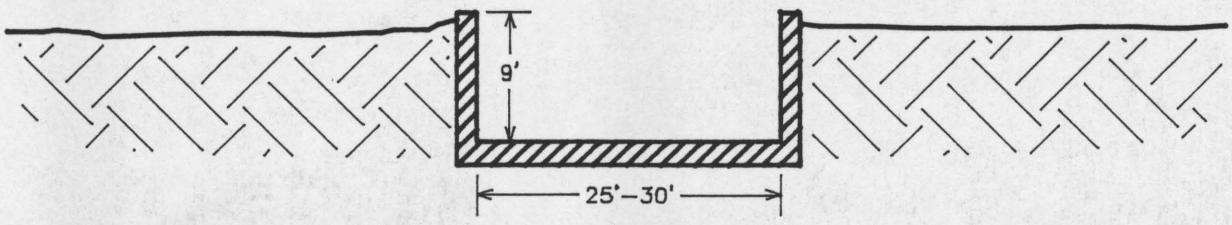
Sediment Basin



Debris Basin



Reinforced Concrete Outlet Channel



Grass-Lined Diversion

Runoff from the upper sugarcane fields will be intercepted by the 5,800-foot long vegetated earth diversion channel. Riprap protected inlets will be provided where the diversion intercepts a drainageway. The diversion bottom width will vary from 11 to 18 feet. Side slopes will be shaped at 2:1. Average channel depth will be nine feet.

Three sediment basins will be constructed along the diversion to trap sediment. A 75-foot long grouted rock chute will also be constructed at the middle sediment basin to accommodate a grade change.

The embankment height on the downslope side of the channel will generally be two to three feet, including freeboard. Embankments up to ten feet high will be required at two locations, at the sediment basin near Wainee Village and at the sediment basin near Kauaula Stream. Catastrophic failure of the embankment could release a maximum discharge of 1,000 cubic feet per second (cfs).

Up to five households located along the proposed alignment of the earth channel in Wainee Village may be relocated. Relocation of four Pioneer Mill Company pipelines and three road crossings and acquisition of 15.4 acres of right of way will also be required for installation of the earth channel and sediment basins. Of the required right of way for this reach, 14.4 acres are classed "prime" or "other important" agricultural land.

Five overflow areas along the diversion will be constructed to allow release of flows exceeding the 50-year design discharge. Channel freeboard will be eliminated at these locations and the excess discharge will be

allowed to spill over natural ground. The released flows will remain in existing drainageways.

Debris Basin

A debris basin will be installed at the junction of the diversion and Kauaula Stream. The debris basin will trap boulders and cobbles transported by the high gradient Kauaula Stream. The basin will be a flow-through structure with no flood storage or detention capability. Debris storage capacity is 8,700 cubic yards or 11,350 tons.

The debris basin will be partially excavated with a horseshoe shaped earth embankment that rises a maximum of 23 feet from the natural ground. Although extremely slight, the threat of loss of life or major property damage due to an embankment breach exists in the Puamana Subdivision and on Honoapiilani Highway. In the event of an embankment breach with embankment-full conditions, it is estimated that a wavefront one to two feet deep will be produced across Honoapiilani Highway.

Rock riprap chutes will convey flows from the diversion and from Kauaula Stream into the debris basin. A reinforced concrete rectangular outlet channel with a 30-foot bottom width will transport the flow to the existing reinforced concrete channel under the Pioneer Mill cane road bridge and Honoapiilani Highway bridge.

A 110-foot wide earth emergency spillway will be provided. Emergency spillway discharge will flow to the south of the basin and will cross Honoapiilani Highway in wide sheet flow approximately 1,300 feet south of the Kauaula Stream bridge. An 18-inch diameter reinforced concrete pipe with a perforated riser will be used to drain the sediment pool.

An emergency action plan and an inundation map showing discharge from a sudden dam breach and from the emergency spillway will be prepared following final design of the debris basin and before commencement of construction. A preliminary dam breach map (Figure B-3) is included in the appendix.

Approximately 3.61 acres of right of way will be required for installation the debris basin. All of the right of way required is classed "prime" agricultural land.

Kauaula Stream Outlet Channel

The 800-foot outlet channel through the Puamana subdivision will be reconstructed along its present right of way. The existing trapeziodal concrete-rock-masonry (CRM) channel will be removed and replaced with a reinforced concrete rectangular channel. The channel will be 25 feet wide, nine feet deep, and will connect smoothly with the Honoapiilani bridge opening.

The existing Front Street bridge and pedestrian bridge will be retained. An internal splitter wall will extend from just upstream of the Front Street bridge to the ocean outlet to limit water surface elevation around curves. The channel will be fenced along its perimeter.

Dissipation of stream energy will be accomplished by discharge into the ocean. The outlet is a naturally formed stream mouth with a bedrock and coral bottom lined with cobbles and boulders.

No right of way will be required for this plan element.

PERMITS AND COMPLIANCE

Installation of the proposed measures will be performed in full compliance with all laws and policies of county, state, and federal requirements.

County of Maui requirements are as follows:

1. GRADING, GRUBBING, EXCAVATING, AND STOCKPILING PERMIT
   Maui County Central Coordinating Agency
   Department of Public Works
   200 S. High St.
   Wailuku, HI 96793

2. SPECIAL MANAGEMENT AREA PERMIT
   Maui County Central Coordinating Agency
   Department of Public Works
   200 S. High St.
   Wailuku, HI 96793

State of Hawaii requirements are as follows:

1. HISTORIC PROPERTY REVIEW –
   Department of Land and Natural Resources, State Parks
   1151 Punchbowl St.
   Honolulu, HI 96813

2. STREAM CHANNEL ALTERATION PERMIT
   Department of Land and Natural Resources, DOWALD
   1151 Punchbowl St.
   Honolulu, HI 96813

3. SPECIAL USE PERMIT
   Department of Business and Economic Development
   Land Use Commission
   335 Merchant St.
   Honolulu, HI 96813

4. SHORE AND SHOREWATERS PERMIT
   Department of Transportation, Harbors Division
   79 S. Nimitz Hwy.
   Honolulu, HI 96813

5. STATE HIGHWAYS PERMIT
   Department of Transportation, Highways Division
   869 Punchbowl St.
   Honolulu, HI 96813.

Federal requirements for permits are as follows:

1. DEPARTMENT OF THE ARMY PERMIT (404)
   U.S. Army Corps of Engineers
   Pacific Ocean Division
   Building 230
   Fort Shafter, HI 96858

COSTS

The total installation cost is estimated to be $5,815,600 of which $4,732,900 will be financed with PL-566 funds and $1,091,700 by the local sponsors. (Tables 1 and 2) This includes the costs of constructing the proposed structural measures, engineering services, project administration, landrights, and relocation assistance costs. All costs reflect the 1990 price base.

Total construction costs include the costs of constructing the earth diversion, sediment basins, debris basin, and reinforced concrete channels. Construction costs are based on quantity estimates and recent unit prices for similar work done in Hawaii. Total construction costs are estimated at $3,799,500 and are entirely PL-566 costs.

Engineering services costs include the direct costs of engineers and others required for design-level investigations, engineering design, preparation of construction specifications, and construction inspection. Engineering services costs are estimated at 15 percent of total construction cost and equal $569,900. Construction inspection costs are estimated to be $171,000. The sponsors and SCS will bear the costs of construction inspection that each incurs. Aside from a portion of construction inspection, all engineering services are PL-566 costs.

Project administration costs include the costs of preparing invitations to bids, administering contracts, and overhead costs of project installation including legal opinions where needed. Project administration costs are estimated at eight percent of total construction costs and equal $304,000, of which $152,000 are PL-566 funds and $152,000 are other funds.

Land rights costs, which include the costs for the acquisition of 20.4 acres of land, related surveys and legal costs, costs for the construction or reconstruction of road crossings, and costs for the relocation of pipelines and utility lines, are estimated at $892,200, all of which are local costs.

Relocation assistance for five households in Wainee Village will cost an estimated $250,000, of which $202,500 are PL-566 funds and $47,500 are other funds.

Annualized costs are computed by adjusting installation and operation, maintenance, and replacement (OM&R) costs to present value then amortizing the total at 8-7/8 percent for the 50-year life of the project. Annualized costs are attributable to flood prevention and are considered adverse effects in the NED account.

INSTALLATION AND FINANCING

The installation period for the Recommended Plan is three years. During the first year the design of the structural measures, preparation of specifications, and surveying and acquisition of right of ways will be started. Construction of the reinforced concrete outlet channel will also take place during the first year. Relocation of affected households will begin during the second year. The debris basin will be constructed during the second year. During the third year, relocation of households will be completed and construction of the diversion channel will take place. The planned sequence for construction of the structural measures will generally proceed from the downstream improvements and work upstream.

Table G shows the estimated schedule for obligating PL-566 and other funds during the three year installation period.

TABLE G - SCHEDULE OF OBLIGATIONS
Lahaina Watershed, Hawaii
(Dollars) 1/

Year	Items	PL-566 Funds	Other Funds	Total
1	Structural	1,343,700	45,200	1,388,900
	Landrights	0	126,400	126,400
	Relocation Assistance	101,500	24,000	125,500
2	Structural	1,160,700	39,000	1,199,700
	Landrights	0	765,800	765,800
	Relocation Assistance	101,000	23,500	124,500
3	Structural	2,017,000	67,800	2,084,800
	Landrights	0	0	0
	Relocation Assistance	0	0	0
TOTAL		4,723,900	1,091,700	5,815,600

1/ Price Base 1990 December 1990

Responsibilities

The County of Maui will be responsible for acquiring the necessary permits, licenses and other entitlements to install the proposed structural measures in the Recommended Plan.

The County of Maui will be responsible for financing all non-federal costs (designated as "Other Funds" in Tables 1 and 2), obtaining rights of way, contracting, and maintaining coordination with federal and state agencies. The County will be responsible for designing and inspecting all road crossings or modifications to road crossings made necessary by the plan.

Relocation of pipelines and utility lines will also be the responsibility of the County.

The County will be responsible for providing relocation assistance to households affected by project installation.

The SCS will be responsible for financing all PL-566 costs as summarized in Tables 1 and 2, preparing all designs for the flood protection works of improvement, and providing construction inspection services for the flood protection works.

Contracting

Formal contracts for the installation of the Recommended Plan, awarded after receipt of competitive bids, will be used. The County of Maui will be responsible for administration of the contracts and for dealing with SCS during installation.

Landrights and Relocations

Landrights acquisition and household relocation will follow the procedures outlined in the Uniform Relocation Assistance and Real Property Acquisition Act of 1970 (P.L. 91-646).

The County of Maui will be responsible for acquiring the 20.4 acres of rights of way required for the installation of the plan. The County will use its power of eminent domain if necessary.

Up to five households in Wainee Village may relocated. Relocation advisory services will be provided by the Sponsors. Four Pioneer Mill pipelines and

several utility service poles in the vicinity of Wainee Village will be relocated.

Cultural Resources

No known cultural resources of national or state signficance will require protection, preservation, or recovery due to the installation of the recommended plan. If cultural resources are uncovered during construction, the SCS will provide appropriate notice to the State Historic Preservation Officer and the U.S. Secretary of the Interior in accordance with the procedures outlined in the SCS General Manual Title 420, Part 401 (October 1983) as amended. SCS will take action to protect or recover, or both, any significant cultural resources discovered during construction.

Financing

The County of Maui will finance its portion of the costs from its general fund.

Federal assistance for installing the Recommended Plan will be provided under the authority of the Watershed Protection and Flood Prevention Act, Public Law 566, 83rd Congress, 68 Stat, 666, as amended (PL-566).

Conditions for Providing Assistance

This Plan-EA does not constitute a document for obligation of PL-566 or other funds. Financial or other assistance furnished by SCS in carrying out the plan is contingent upon appropriation of funds for this purpose.

The Sponsors will ensure full conformance with county, state, and federal laws and regulations.

OPERATION, MAINTENANCE AND REPLACEMENT

The operation, maintenance, and replacement (OM&R) of structural measures will be the responsibility of the County of Maui for the 50-year evaluation period. Prior to signing a project agreement, an Operation and Maintenance Agreement will be entered into by the County and SCS. The agreement will be based on the SCS National Operation and Maintenance Manual 180-V of June 1982 and Amendments and will provide guidelines for operation, maintenance, and replacement of each structural measure.

All works of improvement will be inspected annually and after unusually severe events or conditions to determine the maintenance required. The inspection party will consist of representatives of the County of Maui and the West Maui SWCD. SCS representatives will participate in the inspections during the first five years following project completion. The County will prepare a report for each inspection and submit a copy to SCS.

The following describes the essential elements of the OM&R responsibilities of the County.

1. Earth diversion - Obstructions to channel flow such as debris, large rooted plants, trash, and sediment deposits are to be removed. Scoured areas and scour causes are to be corrected. Sideslopes must be maintained.

2. Concrete channels - Adequate backfill must be maintained along exterior sidewalls. Weepholes are to be kept free of obstructions. Assure surfaces are aligned and show no signs of stress. Monitor concrete channel sidewalls and floor for signs of damage from debris or cavitation scour and repair when necessary.

3. Sediment and debris basin - Maintain adequate storage capacity. Clean out at regularly scheduled intervals and when storage limits are neared.

The average annual cost for OM&R is estimated to be $45,400.

TABLES

Tables 1, 2, 4, 5, and 6 display the estimated installation cost of the structural measures, annualized costs, annualized benefits, and the benefit:cost ratio of the recommended plan. Tables 3 and 3B describe the structural works of improvement.

TABLE 1 - ESTIMATED INSTALLATION COST
Lahaina Watershed, Hawaii
(Dollars) 1/

Installation Cost Item	Unit	Number	Estimated Cost PL-566 Funds SCS 2/ 3/	Other Funds 3/	Total
STRUCTURAL MEASURES					
Channel Work	Miles	1.23	4,723,900	1,091,700	5,815,600
SUBTOTAL STRUCTURAL			4,723,900	1,091,700	5,815,600
TOTAL PROJECT			4,723,900	1,091,700	5,815,600

1/ Price base 1990. December 1990
2/ Federal agency responsible for assisting in installation of works of improvement.
3/ All improvements to be installed on Nonfederal Land.

TABLE 2. ESTIMATED COST DISTRIBUTION
STRUCTURAL AND NONSTRUCTURAL MEASURES
Lahaina Watershed, Hawaii
(Dollars) 1/

Item	INSTALLATION COSTS -- PL-566 FUNDS					INSTALLATION COSTS -- OTHER FUNDS						TOTAL INSTALL. COST
	Construction	Engineering	Relocation Payments	Project Admin.	Total PL-566	Construction	Engineering	Land Rights	Relocation Payments	Project Admin.	Total Other	
STRUCTURAL MEASURES												
Startup 2/	120,200	18,000	0	4,800	143,000	0	0	0	0	4,800	4,800	147,800
Channel Work												
0+00 to 7+80	1,009,000	151,300	0	40,400	1,200,700	0	0	0	0	40,400	40,400	1,241,100
7+80 to 14+30 3/	139,800	21,000	0	5,600	166,400	0	0	0	0	5,600	5,600	172,000
14+30 to 83+30	1,062,600	159,400	202,500 4/	42,500	1,467,000	0	0	710,800 5/	47,500 4/	42,500	800,800	2,267,800
83+30 to 94+54	567,800	85,200	0	22,700	675,700	0	0	39,900 6/	0	22,700	62,600	738,300
94+54 to 96+30	64,500	9,700	0	2,600	76,800	0	0	15,100	0	2,600	17,700	94,500
Debris basin												
9+30 to 14+30	835,600	125,300	0	33,400	994,300	0	0	126,400	0	33,400	159,800	1,154,100
SUBTOTAL STRUCTURAL	3,799,500	569,900	202,500	152,000	4,723,900	0	0	892,200	47,500	152,000	1,091,700	5,815,600
SUBTOTAL NONSTRUCTURAL	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL INSTALLATION	3,799,500	569,900	202,500	152,000	4,723,900	0	0	892,200	47,500	152,000	1,091,700	5,815,600

1/ Price Base 1990

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2/ Includes mobilization, demobilization, field office, pollution control, and clearing and grubbing

3/ Existing channel and bridges and proposed debris basin

4/ Relocation of five households in Wainee Village

5/ Includes relocation of four Pioneer Mill pipelines and construction of three culverts for Pioneer Mill roads

6/ Includes crossing over reinforced concrete channel

TABLE 3 - STRUCTURAL DATA
DAMS WITH PLANNED STORAGE CAPACITY
Lahaina Watershed, Hawaii

Item	Unit	Debris Basin
Class of Structure		C
Seismic Zone		2
Uncontrolled Drainage Area	Sq. Mi.	6.85
Controlled Drainage Area	Sq. Mi.	0
Maximum Inflow	CFS	9,000 1/
Runoff Curve Number (1 day)(AMC II)		57
Time of concentration (Tc)	Hr.	0.83
Elevation - Top of Dam	Ft. MSL	52.5
Elevation - Emergency Spillway	Ft. MSL	49.0
Elevation - Principal Spillway	Ft. MSL	32.5
Elevation - Sediment Pool Drain	Ft. MSL	26.0
Maximum Height of Dam	Ft.	23
Volume of Fill	Cu. Yd.	32,300
Total Capacity 2/	Ac. Ft.	22.4
Submerged	Ac. Ft.	0.0
Sediment Aerated	Ac. Ft.	3.7
Floodwater Retarding	Ac. Ft.	0.0
Between High and Low Stage	Ac. Ft.	4.9
Surface Area		
Sediment Pool	Ac.	0.7
Floodwater Retarding Pool	Ac.	N/A 3/
Low Stage Inlet-Sediment Pool Drain Design		
Drain Type	Reinforced Concrete Pipe with Perforated Riser	
Drain Diameter	In.	18
Principal Spillway Design		
Design Discharge	CFS	5,915
Spillway Type	Reinforced Concrete Channel	
Bottom Width	Ft.	30
Emergency Spillway Design		
Spillway Type	Vegetated Earth	
Bottom Width	Ft.	110
Spillway Exit Slope	Percent	2

1/ Limited by upstream channel capacity.
2/ Crest of emergency spillway.
3/ Not applicable.

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TABLE 3B - STRUCTURAL DATA - CHANNEL WORK
Lahaina Watershed, Hawaii

Channel Reach	Station	Drainage Area Sq. Mi.	50-Year Frequency Design Discharge CFS	Water Surface Elevation Ft. MSL	Hydraulic Gradient Ft./Ft.	CHANNEL DIMENSIONS				"n" value		Velocity Ft./Sec		Excavation Volume Cu. Yd.	Type of Work 3/	Existing Channel Type 4/	Present Flow Condition 5/
						Bottom											
						Gradient Ft./Ft.	Width Ft.	Elevation Ft. MSL	Side Slope	Aged 1/	As Built 2/	Aged 1/	As Built 2/				
Puamana Outlet	0+00	6.85	5915	1.78			50.0	-1.54	0	.014	.014	38.3	24.7		II	M (1967)	I
	1+30	6.85	5915	6.38	.034	.010	25.0	-0.08	0	.014	.014	38.2	26.3	370	II	M (1967)	I
	4+80	6.85	5915	9.06	.032	.047	25.0	3.42	0	.014	.014	43.7	34.5	998	II	M (1967)	I
	8+00	6.85	5915	24.69	.0705	.047	25.0	18.45	0	.014	.014	37.9	31.3	912	II	M (1969)	I
	9+30	6.85	5915	31.47	.0522	.047	25.0	24.50	0	.014	.014	33.9	28.2	247	II	M (1969)	I
	9+80	6.85	5915	34.74	.0654	.080	30.0	28.50	0	.014	.014	31.6	25.0	1231	II	M (1969)	I
	10+30	6.85	5915	40.00	.0351	.080	30.0	32.50	0	.014	.014	26.3	18.5	2019	II	N	I
Debris Basin	10+60	6.85	5915	44.36	.1453	.000	30.0	32.50	0	.014	.014	16.6	11.9	1713	II	N	I
	11+25	6.85	5915	49.28	.0757	.000	100.0	32.50	0	.014	.014	3.5	2.5	4018	II	N	I
	11+50	6.85	5915	49.47	.0038	-.130	100.0	26.00	3	.035	.030 6/	1.5	1.0	2580	II	N	I
	13+50	6.85	5915	49.51	.0002	.000	100.0	26.00	3	.035	.030 6/	1.5	1.0	30,685	II	N	I
	14+30	2.57	1700	49.60	.0011	.175	12.0	40.00	2	.035	.035	5.7	9.8	7/	I	0	E
Earth Diversion with Sediment Basins	16+00	2.57	1700	50.17	.0034	.000	80.0	40.00	2	.035	.030 6/	1.7	1.6	3715	I	0	E
	18+00	2.57	1700	50.19	.0001	.000	80.0	40.00	2	.035	.030 6/	1.7	1.6	7037	I	0	E
	19+00	2.57	1700	49.90	-.0029	.0035	18.0	40.35	2	.035	.030 6/	4.8	5.9	1889	I	0	E
	56+00	2.57	1700	60.65	.0029	.0035	18.0	53.30	2	.035	.030 6/	7.1	6.7	53,222	I	0	E
	57+50	2.57	1700	61.56	.0061	.000	60.0	51.00	2	.035	.030 6/	2.0	1.5	3583	I	0	E
	58+50	1.98	1400	63.10	.0154	.130	11.0	57.40	2	.035	.030 6/	11.0	9.5	1833	I	0	E
	58+60	1.98	1400	64.54	.1440	.004	15.0	57.44	2	.035	.030 6/	6.8	5.8	113	I	0	E
	59+00	1.98	1400	64.67	.0033	.004	15.0	57.60	2	.035	.030 6/	6.8	5.9	452	I	0	E
	80+00	1.98	1400	72.86	.0040	.004	15.0	66.00	2	.035	.030 6/	7.1	6.7	25,945	I	0	E
	81+00	1.98	1400	73.71	.0085	-.030	75.0	63.00	2	.035	.030 6/	1.4	1.0	2833	I	0	E
	83+00	1.98	1400	73.72	.0001	.000	75.0	63.00	2	.035	.030 6/	1.4	1.0	9722	I	0	E
High Velocity Channel	84+15	1.49	950	77.58	.3700	.333	8.0	74.00	0	.014	.014	33.2	28.8	546	IL	0	E
	94+24	1.49	950	124.59	.0466	.043	8.0	117.09	0	.014	.014	15.8	13.2	1182	IL		
Inlet Basin	95+00	1.49	950	128.84	.0003	.000	30.0	120.00	2	.035	.030 6/	2.3	1.8	2696 8/	I	0	E

1/ Velocities associated with design discharge (50-year).
2/ Velocities associated with 10-year frequency discharge.
3/ I - Establishment of new channel, including necessary stabilization measures.
IL - Same as I with impervious lining.
II - Enlargement or realignment of existing channel or stream.
VL - Stabilization of channel using impervious lining. Present capacity adequate.
4/ N - An unmodified, well-defined natural channel or stream.
M( ) - Manmade or previously modified channel with original construction date in parenthesis.
0 - None or practically no defined channel.
5/ I - Intermittant - continuous flow through some seasons of the year but little flow through other seasons.
E - Ephemeral - flows only during periods of surface runoff, otherwise dry.
6/ .030 is used as "As Built" roughness for earth channels due to rocky earth conditions.
7/ Included in previous entry.
8/ Includes excavation to Sta. 96+30.

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TABLE 4 - ANNUALIZED ADVERSE NED BENEFITS
Lahaina Watershed, Hawaii
(Dollars) 1/

Evaluation Unit	PROJECT OUTLAYS: Amortization of Installation Cost	PROJECT OUTLAYS: Operation, Maintenance and Replacement Cost	OTHER PROJECT COSTS: Other Direct Costs	Total
STRUCTURAL				
Channel Work	439,900	35,600	0	475,500
GRAND TOTAL	439,900	35,600	0	475,500

1/ Price base 1990. Discounted and annualized at 8-7/8 percent discount rate for 50 years. December 1990

TABLE 5 - ESTIMATED ANNUALIZED FLOOD DAMAGE REDUCTION BENEFITS
Lahaina Watershed, Hawaii
(Dollars) 1/

Item	Estimated Average Annual Damage		Damage Reduction Benefit	
	Without Project	With Project	Average Annual	Annualized
FLOODWATER				
Agriculture				
Crop	5,000	500	4,500	4,500
Other Agricultural	5,700	600	5,100	5,100
Urban				
Residential	195,600	19,200	176,400	148,200
Commercial	389,700	30,700	359,000	302,000
Floodproofing Cost	71,500	19,800	51,700	43,500
Public Agency	4,200	400	3,800	3,200
Subtotal	671,700	71,200	600,500	505,000
SEDIMENT				
Red Water	107,900	38,700	69,200	58,100
Subtotal	107,900	38,700	69,200	58,100
GRAND TOTAL	779,600	109,900	669,700	563,100

1/ Price base 1990 December 1990

TABLE 6 - COMPARISON OF NED BENEFITS AND COSTS
Lahaina Watershed, Hawaii
(Dollars) 1/

Evaluation Unit	Flood Prevention Annualized Benefits 2/				Annualized Costs 3/	Benefit: Cost Ratio
	Floodwater		Sediment			
	Agriculture	Urban	Red Water	Total		
STRUCTURAL						
Channel Work	8,100	496,900	58,100	563,100	475,500	1.18:1.0
TOTAL	8,100	496,900	58,100	563,100	475,500	1.18:1.0

1/ Price base 1990 December 1990
2/ From Table 5.
3/ From Table 4.

EFFECTS OF RECOMMENDED PLAN

GENERAL IMPACTS

This section describes the economic, environmental, and social effects of the Recommended Plan. The Recommended Plan addresses the concern of flood prevention

Flood Prevention

The Recommended Plan will provide a 50-year level of flood protection to the southern section of Lahaina Town, which includes the Lahaina Historic District, and to the sugarcane fields located below the proposed diversion channel. In the event of a 50-year flood, the proposed measure will prevent flood and sediment damage to 98 residences, 35 condominium units, and 20 commercial units. Flooding due to low area ponding of runoff generated below the diversion will continue to affect 61 residences, 114 businesses, two schools, roads, and parks, although at a much reduced level. The total damage reduction to residential and commercial buildings for the 50-year flood is estimated to be $2,933,300. Residual damage due to ponding during the 50-year flood is estimated to be $1,204,700.

The average annual commercial and residential flood damage reduction is estimated to be $590,900. The cost of floodproofing new buildings will be reduced by an average of $51,700 per year. Costs for storm cleanup and emergency services will be reduced by $3,800 on a average annual basis.

Floodwater damage on 59 acres of sugarcane and to agricultural improvements will also prevented. Agricultural damage reduced by an average of $9,600 per year.

Flooding due to runoff generated above the proposed diversion will continue to occur during storm events exceeding the 50-year recurrence interval, although at a reduced level. Flooding will also continue to occur as a result of runoff originating from the area below the proposed diversion. The project's effect on the 100-year and 500-year floodplains are shown on Figure B-1 and Figure B-2, respectively.

The incidence of road closures and traffic problems caused by flooding and sediment deposition will be reduced. Access by emergency units, such as ambulances, fire and rescue trucks, police vehicles, and utility service trucks, will be improved.

The threat to human safety and health caused by floodwater and sediment deposition on the floodplain will be markedly decreased with installation of the project. The discharge of the 100-year flood across Front Street will be reduced from a maximum depth of 1.8 feet vith a velocity of 0.5 feet per second to 1.3 feet with a velocity of 0.2 feet per second. The 100-year flood through the Kauaula Subdivision will be reduced from a maximum depth of 1.5 feet with a velocity of 2.0 feet per second to 0.5 feet with a velocity of 0.7 feet per second. The increase in security during floods will improve the quality of life in the benefit area.

Sedimentation

Sediment discharge into the fringing reef area fronting Lahaina Town will be virtually eliminated. Currently, an average of 3,400 tons of sediment

are discharged into the area yearly. This area, from the northern boundary of the watershed to just north of Kauaula Stream, is valuable to Lahaina's tourism-based commercial operators and for shoreline and nearshore recreational pursuits. Although "red water" episodes will continue to occur as a result of storm runoff along the entire West Maui coastline, peak suspended sediment concentrations and the duration of the episodes will be significantly reduced in the area fronting Lahaina Town. The marine habitat within the fringing reef fronting Lahaina Town will be enhanced by the reduction of sediment.

The total average annual runoff volume, of both water and sediment, discharged at the Kauaula Stream outlet will be increased. Although coarse sediment discharge (>6" diameter) will be eliminated, fine sediment discharge (clay and silt) will increase during high runoff events. Total average annual sediment discharge at Kauaula Stream will be increased by 1,680 tons per year or by 146 percent due to the diversion of Lahaina subwatershed runoff. The total sediment discharge at Kauaula Stream as the result of a 50-year storm will decrease from 13,400 tons to 11,200 tons.

Sediment ejected at the Kauaula Stream mouth will be predominantly clays and silts which will remain suspended in the water column until still water is reached. The absence of an fringing reef at the Kauaula opening allows a more vigorous wave climate and stronger circulation patterns which will rapidly dissipate the fine sediment.

The marine ecosystem at the Kauaula Stream mouth has less species diversity than within the fringing reef fronting Lahaina Town and is naturally adapted to periodic freshwater and sediment inundation. The increased

discharges of freshwater and fine sediment are expected to have little significant impact at the Kauaula Stream outlet.

Income losses to hotels and ocean-based commercial operations in the watershed due to "red-water" will be reduced by $69,200 annually. Recreational opportunities will be increased.

Visual Resources

The alternative proposes the construction of a diversion, a sediment basin and channel outlet, and modifications to the Kauaula Stream channel, all of which will have some impact on the area's visual resources.

The proposed diversion will be located across the slope above Lahaina Town at the 50-foot to 80-foot elevation and 400 to 1,500 feet uphill from Honoapiilani Highway. The grassed channel embankment may be visible from the highway and Lahaina Town. Mature sugarcane will provide screening during the majority of the time.

The debris basin will be located on Kauaula Stream 200 feet above Honoapiilani Highway and will be visible from the highway. Vegetative screening and architectural concrete colors and textures will be considered to reduce the visual impact of the basin.

Cultivation practices by the sugar company have produced landscape forms that are similar to those proposed by this plan. Terraces, irrigation and storm ditches, and field roads follow the contour of the hillside as will the diversion channel. Large rock piles that dot the Lahaina sugarcane fields are similar in form to the proposed debris basin embankment.

Improvements to Kauaula Stream by the the Recommended Plan include replacement of existing trapeziodal cement rock masonry outlet channel through the Puamana Subdivision with a rectangular reinforced concrete concrete channel. As the rectangular channel will have a narrower top width the additional area adjacent to the channel can be landscaped to screen the channel.

Geologic Hazard

Earth embankments will be constructed for the diversion channel and basins. The embankment for the debris basin on Kauaula Stream will rise a maximum of 23 feet and will be regarded as a "class C hazard" dam. The island of Maui is in Seismic Zone 2 indicating moderate seismic activity. The debris basin has been designed as a "flow-through" structure with no permanent water storage capacity. Although the likelihood of an earthquake occurring during embankment-full flow is very small, an embankment failure at that time may cause loss of life and may damage buildings, public utilities, and Honoapiilani Highway.

Historic Sites

The installation of the diversion channel and other project improvements will provide flood protection to the Lahaina Historic District. The historic sites located in the Lahaina Historic District are at least one-half mile from the project improvements and will not be affected by project construction.

Significant Effects on Identified Concerns

The Recommended Plan addresses or affects eighteen of the concerns listed in Table B as high or medium in significance to decision making during the scoping process. Those effects are summarized in Table I.

Effects on Nationally Recognized Resources

Certain federal policies and laws recognize specific types of resources. These policies and laws impose specific requirements for analysis of the effects of the Recommended Plan as shown in Table J.

RELATIONSHIP TO LAND AND WATER PLANS, POLICIES, AND CONTROLS

Appropriate clearinghouse procedures have been followed by the Sponsors in processing the application for assistance under PL-566. The notification of application was issued on November 24, 1980, by the State Clearinghouse, Department of Planning and Economic Development. Since 1988, the State Clearinghouse has been a function of the State Office of Planning.

Implementation of the Recommended Plan will complement the objectives of the County of Maui's Lahaina Community Plan.

Table I - SUMMARY OF EFFECTS OF THE RECOMMENDED PLAN
Lahaina Watershed, Hawaii
(Dollars)

NATIONAL ECONOMIC DEVELOPMENT

Beneficial Effects		Adverse Effects	
Components	Measure of Effects (Annualized) 1/	Components	Measure of Effects (Annualized) 2/
A. Flood Protection		A. Value of resources required for project:	
1. Urban	496,900	1. Project installation	439,900
2. Agriculture	8,100	2. OM&R	35,600
B. Sediment Reduction	58,100		
Total Beneficial Effects	563,100	Total Adverse Effects	475,500

Benefit:Cost Ratio = 1.18:1.0

1/ Price base 1990.
2/ Amortized over 50 years @ 8-7/8 percent interest.

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Table I - SUMMARY OF EFFECTS OF THE RECOMMENDED PLAN
Lahaina Watershed, Hawaii

Page 2 of 3

Economic, Social, Environmental, and Cultural Concerns	Effects
Floodwater and sediment damage to residential and commercial structures.	Reduced by $535,400. (average annual)
Flooding of Lahaina Historic District	50-year level of flood protection provided. Flooding from localized runoff will continue.
Cost of floodproofing new buildings.	Reduced by $51,700. (average annual)
Damage to street surfaces and sediment and debris cleanup.	Reduced by $3,800. (average annual)
Road closures and traffic disruption and congestion.	Reduced.
Access to emergency services.	Improved.
Threat human to health and safety.	Reduced
Quality of life.	Improved
Floodwater and sediment damage to sugarcane crops, fields, roads, irrigation systems, and ditches.	Reduced by $9,600. (average annual)
Tons of sediment entering ocean from watershed.	Reduced by 1,690 tons or by 37 percent per average year.
Income losses for ocean-front hotels.	Reduced by $69,200. (average annual)
Loss of venue for ocean-based businesses.	Incidence reduced.
Ocean recreational opportunity.	Enhanced
Visitor appeal of Lahaina area.	Improved
Threat to coral reef ecosystems.	Reduced

Table I - SUMMARY OF EFFECTS OF THE RECOMMENDED PLAN
Lahaina Watershed, Hawaii

Economic, Social, Environmental, and Cultural Concerns	Effects
Prime and other important farmlands required for project installation.	18 acres required.
Visual resources.	Structural improvements will be visible.
Geologic hazard.	Possibility of basin embankment breach.

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TABLE J - EFFECTS OF THE RECOMMEDED PLAN ON RESOURCES OF PRINCIPAL NATIONAL RECOGNITION
Lahaina Watershed

Types of Resources	Principal Sources of National Recognition	Measurement of Effects
Air quality	Clean Air Act, as amended (42 U.S.C. 185h-7 et seq.)	No significant effect
Areas of particular concern within the coastal zone	Coastal Zone Management Act of 1972, as amended (16 U.S.C. 1451 et seq.)	No effect
Endangered and threatened species critical habitat	Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.)	Not present in planning area
Fish and wildlife habitat	Fish and Wildlife Coordination Act (16 U.S.C. Sec. 661 et seq.)	No significant effect
Floodplains	Executive Order 11988, Floodplain Management	62 acres eliminated from 100-year floodplain.
Historic and cultural properties	National Historic Preservation Act of 1966, as amended (U.S.C. Sec. 470 et seq.)	50-year flood protection to Lahaina Historic District
Prime and unique farmland	CEQ Memorandum of August 1, 1980: Analysis of Impacts on Prime or Unique Agricultural Lands in Implementing the National Environmental Policy Act	Eight acres "prime" farmland lost. Ten acres of "other important" farmland lost.
Water quality	Clean Water Act of 1977 (33 U.S.C. 1251 et seq.)	Reduced total sediment entering ocean from watershed.
Wetlands	Executive Order 11990, Protection of Wetlands Clean Water Act of 1977 (42 U.S.C. 185h-7 et seq.)	Not present in planning area
Wild and scenic rivers	Wild and Scenic Rivers Act, as amended (16 U.S.C. 1271 et seq.)	Not present in planning area
Farmland Protection Policy Act	Public 97-98 - Farmland Policy Act of 1981	No significant effect

December 1990

CONSULTATION AND PUBLIC PARTICIPATION

Agency consultation and public participation were an integral part of project planning and the environmental evaluation conducted by the Sponsors and SCS. All contacts were noted and the results reported and evaluated in the project documentation file.

Formal agency consultation began with the November 10, 1980 notification by SCS, the County of Maui, and the West Maui Soil and Water Conservation District of the Application for Federal Assistance under PL-566 to the Hawaii State Clearinghouse, Department of Planning and Economic Development, as part of the A-95 review process. All federal agencies with possible interest in the project were also notified of the application for assistance. Informal coordination with the Corps of Engineers and the State of Hawaii was also initiated at that time.

Project planning and environmental evaluation began in October 1981 under the direction of SCS. Various meetings were held with the Sponsors, federal, state, county, and local agencies and the public to identify the concerns listed in Table B.

Based on the results of meetings with the Sponsors and the preauthorization studies, SCS requested planning authorization from the SCS Chief in Washington, D.C. This authorization was granted on March 18, 1985, and the agencies and the public were notified.

The U.S. Fish and Wildlife Service (USFWS) was consulted, in accordance with Section 7 of the Endangered Species Act, as amended, concerning threatened and endangered species that may be present in the Lahaina

Watershed. USFWS concurred in a no adverse impact assessment to listed species.

The State Historic Preservation Officer (SHPO) was consulted regarding cultural, historical, and archeological sites within the Lahaina Watershed. SHPO concurred that the proposed project will have no adverse effects on the two sites listed on the National Register and State Register of Historic Places: Lahaina Historic District and Hale Pa'i. SHPO further recommended that an archeological survey be conducted for all areas disturbed by the project.

Following a request by SCS, a Staff Archeologist from the State Historic Sites Section conducted an on-site examination of the diversion alignment to determine if any unrecorded cultural resources would be affected by project installation. The physical inspection resulted in a "negative finding of any evidence of significant cultural resources along the proposed route."

Consultation with SHPO was conducted regarding the historic significance of the five homes in Wainee Village that may be demolished for project installation. After a site examination by SHPO and SCS, SHPO determined that, although Wainee Village meets the criteria for listing in the National Register of Historic Places, the five dwellings, due to their peripheral location and alterations have negligible historic value.

A major consideration in the development of the Plan-EA was to provide interested and affected groups and individuals an opportunity to participate in the planning process. The Sponsors and SCS developed a public participation plan for the Lahaina Watershed to assure a high level

of public participation. Many individual contacts were made with the local residents of the watershed to gather data and to solicit participation in planning and environmental evaluation.

A mailing list was prepared and maintained to ensure timely notification of meetings and distribution of materials. Upcoming meetings and the availability of information were announced in newspaper notices and articles, posters, radio spots, and at meetings of interested groups.

Several public workshops and meetings were held throughout the development of the Plan-EA. A workshop was held in September 1981 to solicit comments from the public regarding the resource problems in the Lahaina Watershed. A meeting was held in December 1985 to further solicit comments from the public regarding the flooding problems in the watershed and to report on planning progress. Another public meeting was held in July 1986 to discuss alternative plans to alleviate the flooding problems.

This Technical Review Plan-EA was distributed for an informal review by SCS technical reviewers and Sponsors. Discussions and comments on the Technical Review copy will be incorporated into the Draft Plan-EA.

The notice of availability of the Draft Plan-EA for the Lahaina Watershed will be published in the Federal Register and local newspapers. The Draft Plan-EA will be distributed for review and comment to interested individuals and to the following agencies or groups:

U.S. Government

Department of Agriculture

Agricultural Stabilization and Conservation Service

Farmers Home Administration

Forest Service

Department of Defense

Army Corps of Engineers

Department of Commerce

National Marine Fisheries

Department of Housing and Urban Development

Department of Health and Human Services

Department of the Interior

Secretary of the Interior

Office of Environmental Affairs

Geological Survey

Fish and Wildlife Service

National Park Service

Department of Transportation

Federal Highway Administration

United States Coast Guard

Environmental Protection Agency

National Organizations

Advisory Council on Historic Preservation

Natural Resources Defense Council

National Wildlife Federation

Sierra Club

National Audubon Society

State of Hawaii

Department of Agriculture

Department of Health

Department of Land and Natural Resources

Historic Preservation Officer

Forestry and Wildlife Division

State Parks, Outdoor Recreation, and Historic Sites Division

Division of Water Resource Management

Department of Planning and Economic Development

Department of Transportation

Highways Division

Office of Environmental Quality Control

County of Maui

Department of Economic Development

Department of Planning

Department of Parks and Recreation

Department of Public Works

Office of the Mayor

Groups

Amfac Investment Properties Inc.

AMFAC JMB Inc.

Bishop Estate

Conservation Council of Hawaii

Hawaii Audubon Society

Hawaii Federation of Fisherman

Hawaii Water Pollution Association

Hawaiian Historical Society

Lahaina Kiwanis Club

Lahaina Outdoor Circle

Lahaina Yacht Club

Life of the Land

Maui Cooperative Fishermen's Association

Maui Historical Society

Nature Conservancy

Pioneer Mill Company, Ltd.

Puamana Community Association

Sierra Club, Hawaii Chapter

Summary of Responses and Comments

Comments on this Technical Review Plan-EA and the responses to those comments are included in Appendix A.

LIST OF PREPARERS AND QUALIFICATIONS

The draft watershed plan and environmental assessment was reviewed and concurred in by state staff specialists having responsibility for engineering, soils, agronomy, biology, and geology. This review was followed by review of the document and supporting data by the SCS West National Technical Center.

NAME	PRESENT TITLE - YEARS	EDUCATION (Degree - Subject)	PAST EXPERIENCE (Title - Years)	OTHER QUALIFICATIONS
SCS HAWAII STATE OFFICE STAFF				
Kenneth M. Kaneshiro	Asst. State Conservationist - 1	BA - Geology	Geologist - 9 Planning Staff Leader - 13	Prof. Geologist - ID
Larry J. Babich	State Conservation Engineer - 2 (Since 1988)	BS - Civil Engineering	Planning Staff Leader - 1 Planning Engineer - 9 Civil Engineer - 6	Prof. Engineer - MT Prof. Engineer - AZ
John W. Bedish	Planning Staff Leader - 1	BS - F&W Management MS - F&W Management	State Resource Conservationist - 14 Soil Conservationist - 5 Environmental Specialist - 1	
Glenn G. Ahuna	Hydrologist - 12	BS - Civil Engineering	Civil Engineer - 8	Prof. Engineer - HI Prof. Engineer - CA
Dudley Y. Kubo	Planning Engineer - 4	BA - History MA - History BS - Civil Engineering	Civil Engineer - 2	Prof. Engineer - HI
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Gail H. Ichikawa	Economist - 10	BS - Agriculture		

LIST OF PREPARERS AND QUALIFICATIONS

NAME	PRESENT TITLE - YEARS	EDUCATION (Degree - Subject)	PAST EXPERIENCE (Title - Years)	OTHER QUALIFICATIONS
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James C. L. Lum	Civil Engineer - 9	BS - Civil Engineering	Agricultural Engineer - 3 Civil Engineer - 2	Prof. Engineer - HI
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WAILUKU FIELD OFFICE				
Ernest Robello, Jr.	RC&D Coordinator - 1	BS - Soil Science	Soil Scientist - 10 Soil Conservationist - 4 District Conservationist - 11	
Charles M. Hamura	Soil Conservationist - 24	BS - Soil Science	Commodities Inspector - 5	
James J. Ino	Soil Conservationist - 8	BS - Agriculture	Soil Conservationist - 1	
Edward P. Perreira	Soil Conservation Tech. - 16		PMC Technician - 8 Independent Farmer	

LIST OF PREPARERS AND QUALIFICATIONS

NAME	PRESENT TITLE - YEARS	EDUCATION (Degree - Subject)	PAST EXPERIENCE (Title - Years)	OTHER QUALIFICATIONS
SCS WNTC PLANNING STAFF				
Thomas T. Fujii	Staff Leader (Since 1988)	BS - Ag. Engineering BA - Business Admin.	Planning Engineer - 4 Irrigation Engineer - 2 Head, EDS - 10 Civil Engineer - 3 River Basin Engineer - 3 Area & Project Engineer - 4 Field Office Engineer - 5	
Peter V. Patterson	Staff Leader - 2 (To 1988)	BS - Geology MS - Structural Geology	Sedimentation Geologist - 1 Natl. Engrng. Geologist - 4 Regional Geologist - 2 Sedimentation Engineer -3 Geotechnical Staff Ldr. - 2 Engineering Geologist - 3 Geologist - 9	Prof. Eng. Geologist - CA Prof. Eng. Geologist - OR Prof. Geol. Scntst. - AIPG
Paul H. Cleary	Planning Engineer - 7	BS - Gen. Engineering	River Basin Staff Leader - 4 Hydraulic Engineer - 8 Civil Engineer - 4	Prof. Engineer - WI
Milton E. Griffing	Agricultural Economist - 7	BS - Agronomy MS - Ag. Economics	RB/WS Ag. Economist - 16	
Joseph W. Sahlfield	Hydraulic Engineer - 5	BS - Ag. Engineering	Design Engineer - 4 Planning Engineer - 2 Civil Engineer - 3 Ag. Engineer - 4	Prof. Engineer - OR

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2. Clark, John, Beaches of Maui County, Honolulu, 1980

3. Department of the Army, U.S. Army Engineer District, Honolulu, Supplemental Information Report to the Final Environmental Statement for the Kahoma Stream Flood Control Project, 1983.

4. Grigg, Richard W., Assessment of Potential Marine Ecological Impacts of the Lahaina Watershed Project, 1983.

5. Grigg, Richard W., Supplemental Reconnaissance Marine Ecology Assessment for the Lahaina Watershed Project, May 1986.

6. Hastings, Martin, Chew & Associates, Ltd., Economic, Demographic and Selected Land Use Forecasts; Proposed Community Development Plans; County of Maui, State of Hawaii, prepared for Aotani & Associated, Inc. and EDAW, Inc., Honolulu, Hawaii, July 1981.

7. State of Hawaii, Department of Land and Natural Resources, Division of Aquatic Resources, Letter of November 14, 1985, regarding potential impacts of the Lahaina Watershed Project on fish resources

8. State of Hawaii, Department of Land and Natural Resources, Field Inspection Report, Lahaina Watershed Flood Control Project, Panaewa - Polanui, Lahaina, Maui, TMK: 4-6-various: and 4-7-various, April 22, 1986.

9. State of Hawaii, Department of Land and Natural Resources, Division of State Parks, Letter of December 2, 1985, regarding potential impacts of the Lahaina Watershed Project on cultural and/or historical sites.

10. U.S. Department of Agriculture, Soil Conservation Service, National Watersheds Manual, Title 390 - Chapter V with Amendment 19, 1981.

11. U.S. Department of Agriculture, Soil Conservation Service, Lahaina Watershed Preauthorization Report, January 1985.

12. U.S. Department of Agriculture, Soil Conservation Service, Lahaina Watershed Alternatives Report, June 1986.

13. Water Resources Council, Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, March 1983.

INDEX

GLOSSARY

alluvial - Of, pertaining to, or composed of sediment deposited by flowing water.

alternatives - Possible designs chosen to fulfill the objectives of a project, one of which will be recommended based upon multidisciplinary criteria.

amortization - The process of liquidating a debt by installment payments; to prorate over a defined period, at a specified interest rate.

architectural form liners - Liners placed into concrete forms to create an esthetic design in the finished concrete surface.

benefits, annualized - Projected annual benefit due to project implementation calculated by summing the present value of all benefits accrued during the project life then amortizing the total over the project period.

benefits, average annual - The long-termed average of the annual benefits expected to occur each year from installation of the project.

benefits, net - The difference between the average annual benefits and the average annual costs; expressed as a negative value when costs exceed benefits.

benefit-cost (B:C) ratio - Average annual benefits divided by the average annual costs or annualized benefits divided by annualized costs.

capacity - The maximum volume that a water conveyance system is capable of transporting, or that a reservoir can hold; the maximum volume that a sediment retaining structure can hold.

conservation - Natural resource management practices that assume a "wise useage" policy; i.e., renewable resources are managed on a sustained yield basis, while nonrenewable types are used with minimum wastage.

conservation plan - A technical assistance provided by SCS to farmers and ranchers; outlines resource management practices which insures their perpetual availability; see also land treatment.

costs, annualized - Annual project cost calculated by adjusting all installation and OM&R costs to present value after which the total is amortized over the project period.

costs, average annual - The average cost incurred each year to pay for a project; usually involves the amortized construction cost plus the annual cost of operation, maintenance, and replacement.

costs, engineering services - Those expenses associated with surveys, investigations, designs, and preparation of plans and specifications.

costs, landrights - The cost of securing easements, right-of-way, and real property; for PL-566 purposes, also includes construction costs of bridges, culverts, and utility modifications.

costs, local - Those expenses borne by the local project sponsors as outlined under PL-566.

costs, other - Expenses borne by nonfederal funding; usually funded by local sponsors.

costs, relocation - All expenses associated with moving of households and businesses from condemned properties.

cross section - A view of an object formed by cutting though it, usually at right angles to its axis.

cubic feet per second (cfs) - A hydraulic term denoting flow rate; equal to 448.8 gpm.

culvert - Any water conveyance structure passing underneath a road or embankment, usually a pipe or reinforced concrete box.

cut - A slope or embankment from which earth is excavated (removed); antonym -- fill.

damage factors - Anticipated damages to crops and/or urban structures expressed as a percentage of the total value of the undamaged crop and/or structure; i.e., a decimal amount which, multiplied by the value of the undamaged crop and/or structure, yields and estimate of damages in dollars.

discharge (Q) - The flow rate of water through any pipe, ditch, culvert, etc.; usually expressed in cfs.

diversion channel - Any channel that redirects the natural flow of flood waters.

diversity, species - The variety of kinds of plants or animals in an area; in general, high species diversity indicates high biological productivity.

ecology - The science of the relationships between organisms and their environment.

ecosystem - The area of influence by all living and nonliving factors in the environment; because of the principal of environmental interrelationship ecosystems always interact with each other.

embankment - A mound of earth and/or stone built to hold back water or support a roadway.

Environmental Quality Plan (EQ) - A plan, or element of a plan, that enhances ecological, cultural, or esthetic aspects of the environment.

erosion - The detachment, transportation, and deposition of soil.

erosion, rill - The erosional action of water that forms small (less than 1 foot deep), steep-sided channels called rills; left unchecked, rills become gullies.

erosion, sheet - The uniform movement of soil on a slope by sheets of running water, as distinct from streams.

excavation - The act of digging out and removing earth from a given area.

fill - Earth material, including rock, placed on a site to form dams or embankments; also used to raise the level of the ground or "fill in" depressions.

filter - A rock or mesh material used where subsurface water drains into a pipe or channel to prevent detachment and movement of soil particles.

fines - The fine fraction of soils and sediment, consisting of clay and silt particles smaller than 0.074 mm. in diameter (by USDA nomenclature).

flood plain - An area subject to flooding; includes lands bordering streams, rivers, ponds, lakes, and undrained lowlands.

flood prone - Areas that are likely to experience inundation by floodwater.

flood proofing - Protecting an individual structure against flood damage by installing such devices as flood walls, flood shields, or ring dikes; also includes elevating the structure above the flood level.

flood shield - A device installed when flood proofing a building which seals an entrance when in place.

flood wall - Impermeable wall placed around and adjacent to a building for flood proofing.

flood warning system - A system or device, usually electronic, that sounds an audible sound when flooding danger is imminent in a local area; e.g., overtopping of dams.

floodwater retarding structure - A dam or reservoir that impounds floodwaters and releases them over an extended period; also called flood water detention structures.

freeboard - The distance between the design water surface and the top of a dam or channel.

habitat - The area where an organism or biological population normally lives or occurs; includes the total area where all physical and biological life requirements of a species are found.

impacts, environmental - Any change in environmental conditions, positive or negative, that occur as a result, direct or indirect, of installing a project or other modification.

incremental benefit-cost analysis - The process by which each individual segment, measure, or structure is separately evaluated in terms of comparing benefits to costs before adding the next segment, measure, or structure.

indigenous - Occurring or living naturally in an area; not introduced; native.

induced flooding - New flooding, and/or increased depth and duration of flooding, caused by the project.

landrights - The ownership of real property and/or its use, temporary or permanent; see also easements and right-of-way.

landscape architecture - The process of designing a view or vista, usually, to enhance the visual resource.

land treatment - Soil and water conservation practices on rural lands that preserve and perpetuate the soil resource base; see also conservation plan.

land use - The service or activity to which a parcel of land is employed; e.g., urban residential, commercial, industrial, conservation, recreation, etc.

natural resources - Those components of the environment which are at least potentially useful to man, both economically and metaphysically; includes minerals, trees, fossil fuels, fish, wildlife, scenery, etc.

National Economic Development Plan (NED) - A plan, or element of a plan, that maximizes net national economic development benefits.

National Environmental Policy Act (NEPA) - A 1970 law that requires each federal agency to prepare an Environmental Impact Statement to assess and avoid adverse environmental impacts in advance of each major action, recommendation, or project, that would significantly affect the quality of the human environment. If the effects on the quality of the human environment are not considered significant, then the less intensive Environmental Assessment is prepared.

nonstructural - Water and sediment management practices that avoid structural modifications and construction; includes flood proofing, flood warning systems, relocation, flood insurance, land use regulation, etc.; see also structural measures.

"n" value - A coefficient of channel roughness used in hydraulic computations; determined by such factors as bed material, bank material, surface irregularity, vegetation, uniformity of cross section, obstructions, and meandering.

operation, maintenance and replacement costs (OM&R) - Costs associated with the general use and repair of channels, reservoirs, structures, and their related rights-of-way.

percent event - Denotes the magnitude of a flood; i.e., a flood that has a certain percent chance of occurring in any one year.

Public Law 83-566 (PL-566) - See Watershed Protection and Flood Prevention Act.

prime agricultural land - Prime farmland that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops, and is also available for these uses (the land could be cropland, pastureland, or other land, but not urban built-up land or water). It has the soil quality, growing season, and irrigation supply needed to economically produce sustained high yields of crops when treated and managed, including water management, according to acceptable farming methods.

probable maximum flood - The amount of surface water produced from a theoretical storm in which all meteorological parameters are maximized at the same time.

reach - A segment of the project area associated with a stream or channel; boundaries are arbitrarily defined and are generally established early in the study.

recurrence interval - The time period (in years) between storms of a specified intensity; inverse of percent event (e.g., 1 percent event = 100-year storm).

reservoir - Any water storage facility.

residual flooding - All surface water flooding recognized to remain in the after project measures have been implemented.

right-of-way - The right to pass over property owned by another party or the property requirement for the installation of structural measures.

riprap - A loose or grouted assemblage of stones placed along the inside slope of a channel or embankment to reduce erosion and provide fortification.

scoping - The process of determining the significant issues to be addressed in the development of a project.

sediment - Solid material, both mineral and organic, that is suspended in or being transported by moving water or has been deposited.

sedimentation - The act or process of eroding, transporting, and depositing sediment.

sediment delivery ratio - The ratio of soil actually transported out of the watershed as sediment to the total amount eroded; usually expressed as percentage.

sediment yield - The amount of soil removed from a drainage basin; only represents a fraction of the total erosion as some material remains in the watershed.

soil - The layer of the earth's surface composed of both organic and mineral elements and capable of supporting plant life.

Soil and Water Conservation District - A local unit of state government that is responsible for soil and water conservation within its boundaries.

soil structure - The arrangement of primary soil particles into larger aggregates termed granular, platy, prismatic, columnar, and blocky.

soil texture - The relative proportions of soil particle sizes found within a given soil sample or type; sizes include silt, clay, sand, and gravel.

species - A fundamental category of classifying living things, ranking after genus, and consisting of organisms capable of interbreeding.

spillway, emergency - An ungated outlet from a reservoir which prevents over topping by floodwater during large storms.

spillway, principal - A structure associated with a dam to allow for controlled releases of water.

spoil - Refuse material removed by digging or dredging.

stage - The elevation of the water surface at any channel or reservoir cross section.

structural measures - Water and sediment management practices that involve the construction of channels, reservoirs, sewers, and other devices; see also nonstructural measures.

value, content - The cash worth of personal property contained within a building subject to flood damage.

watershed - The topographic area drained by a single river or creek system.

Watershed Protection and Flood Prevention Act (PL 83-566) - Administered by the Soil Conservation Service, this law provides technical assistance and cost sharing to local sponsors for developing and implementing plans in watersheds no larger than 250,000 acres; may be multipurpose.

weir - A dam placed in a stream to raise the water level or regulate the flow; often used to divert water into another channel.

APPENDIX A

Significant Comments Received on

Draft Plan - Environmental Assessment

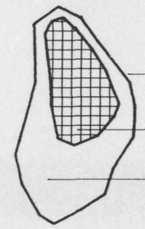
APPENDIX B

Support Maps

B-1	100 Year Urban Floodplain
B-2	500 Year Urban Floodplain
B-3	Breach Inundation Map
B-4	Channel Overflow During 100-Year Storm
B-5	Lahaina Historic Districts Map

100 YEAR URBAN FLOODPLAIN

Lahaina Watershed
Maui County, Hawaii



LEGEND

- 100 Year Floodplain Boundary Without Project
- Area With Flood Depths Reduced by Project
- Area With Flooding Prevented by Project

0 500 1000 2000

FEET

NOTE: Flooding in low areas will continue to result from localized rainfall.

500 YEAR URBAN FLOODPLAIN

Lahaina Watershed
Maui County, Hawaii

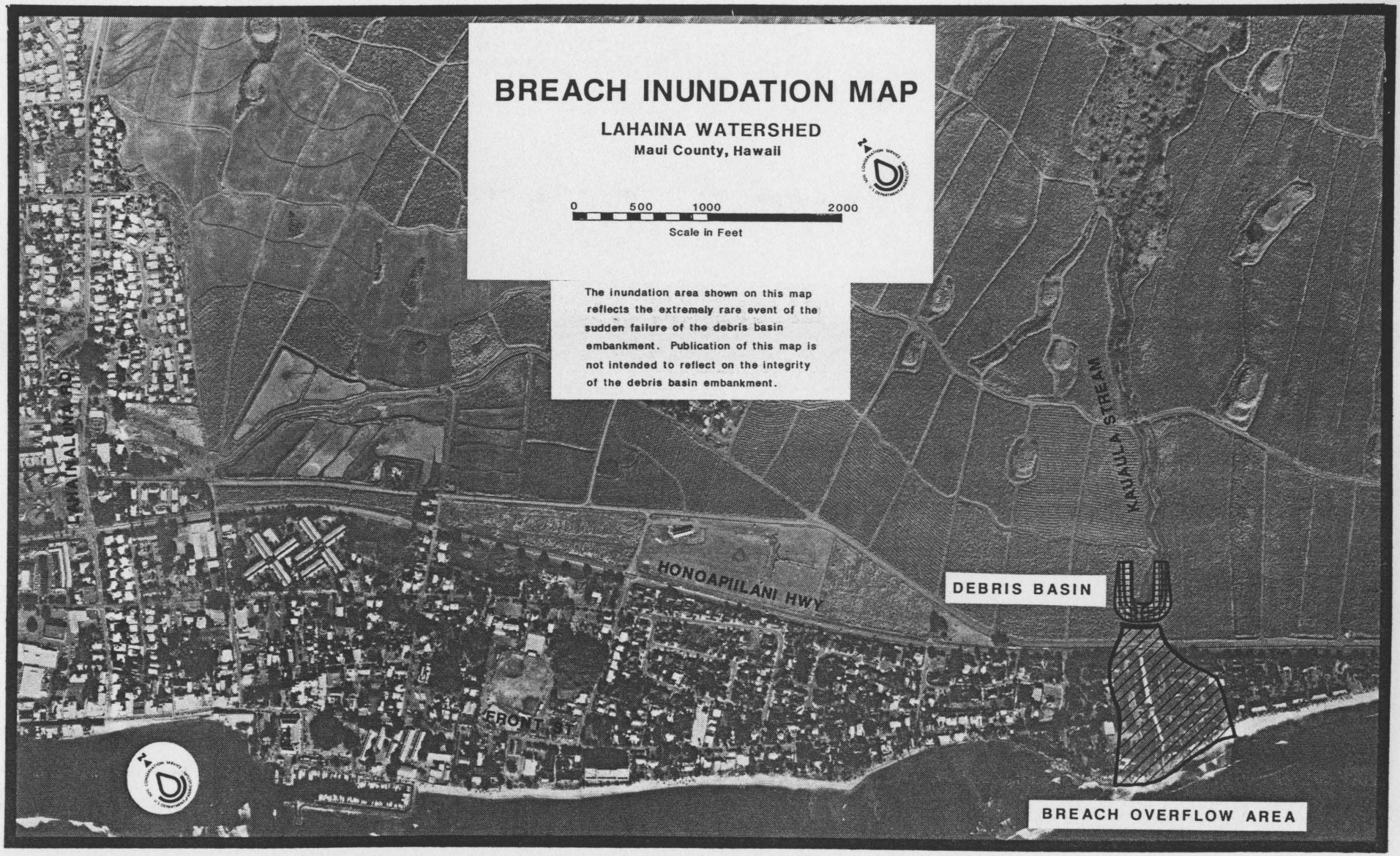
LEGEND

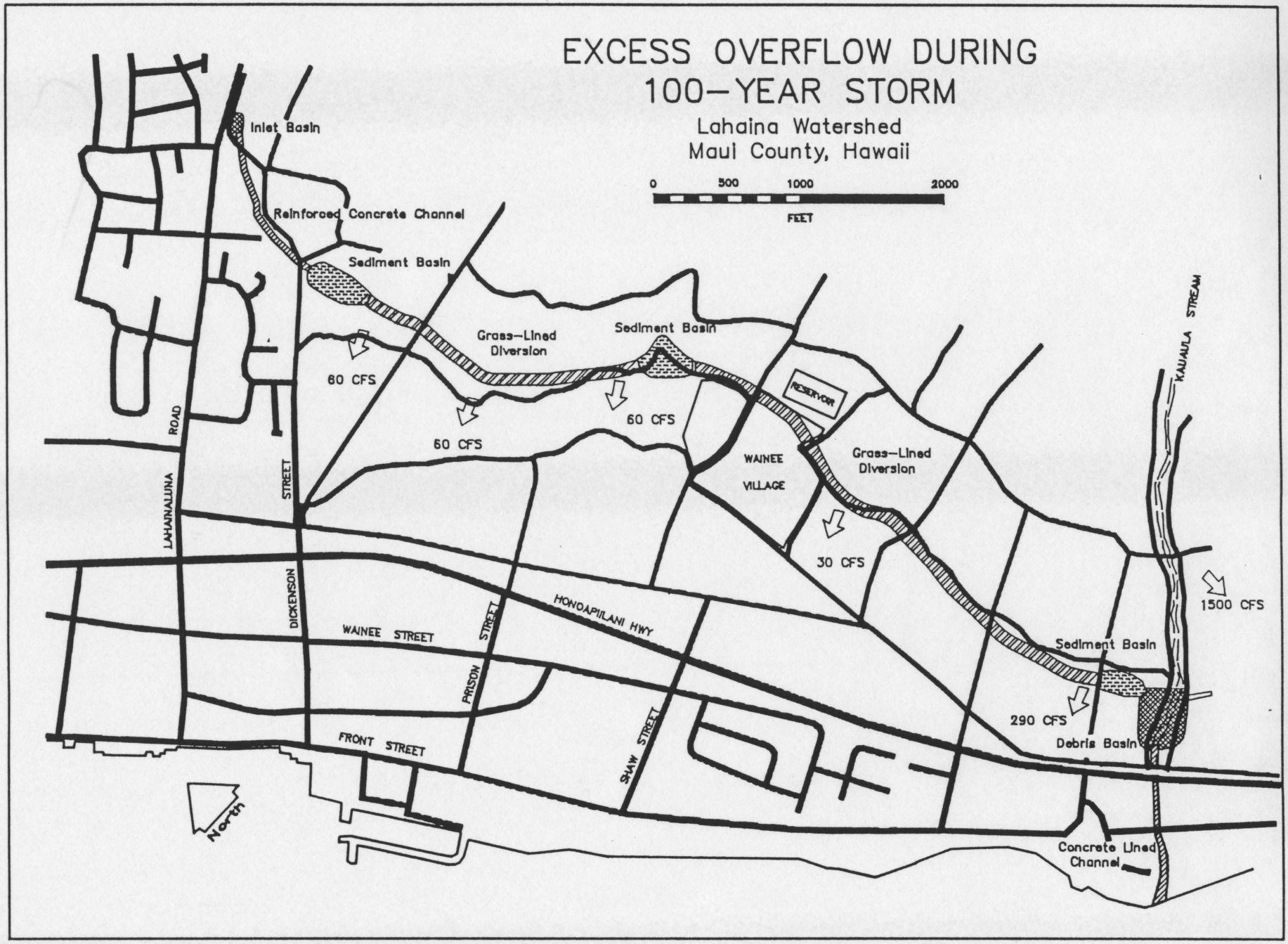
- 500 Year Floodplain Boundary Without Project
- Area With Flood Depths Reduced by Project
- Area With Flooding Prevented by Project

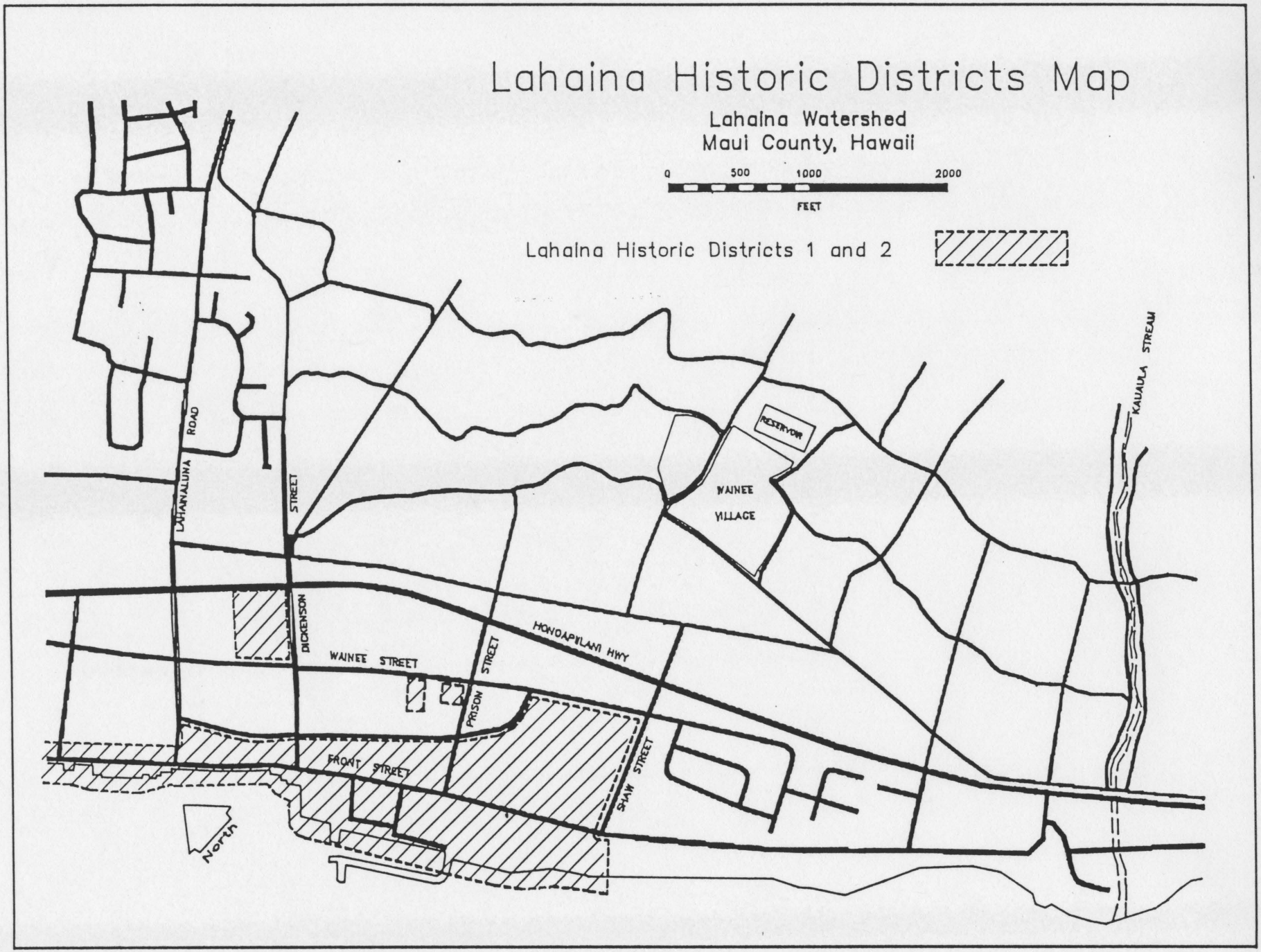
0 500 1000 2000

FEET

NOTE: Flooding in low areas will continue to result from localized rainfall.


BREACH INUNDATION MAP
LAHAINA WATERSHED
Maui County, Hawaii
0 500 1000 2000
Scale in Feet
The inundation area shown on this map reflects the extremely rare event of the sudden failure of the debris basin embankment. Publication of this map is not intended to reflect on the integrity of the debris basin embankment.
HONOAPIILANI HWY
FRONT ST
KAUAULA STREAM
DEBRIS BASIN
BREACH OVERFLOW AREA


EXCESS OVERFLOW DURING
100-YEAR STORM
Lahaina Watershed
Maui County, Hawaii
0
500
1000
2000
FEET
Inlet Basin
Reinforced Concrete Channel
Sediment Basin
Grass-Lined Diversion
Sediment Basin
60 CFS
60 CFS
60 CFS
RESERVOIR
WAINEE VILLAGE
Grass-Lined Diversion
KAUAULA STREAM
30 CFS
1500 CFS
Sediment Basin
290 CFS
Debris Basin
Concrete Lined Channel
LAHAINALUNA ROAD
STREET
DICKENSON
WAINEE STREET
PRISON STREET
HONOAPIILANI HWY
FRONT STREET
SHAW STREET
North


Lahaina Historic Districts Map
Lahaina Watershed
Maui County, Hawaii
0
500
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2000
FEET
Lahaina Historic Districts 1 and 2
LAHAINALUNA ROAD
STREET
DICKENSON
WAINEE STREET
PRISON STREET
FRONT STREET
SHAW STREET
HONOAPIILANI HWY
RESERVOIR
WAINEE
VILLAGE
KAUAULA STREAM
North

APPENDIX C

Investigation and Analyses Report

INVESTIGATION AND ANALYSES

PROJECT FORMULATION

Flooding is a major concern in the town of Lahaina on the island of Maui. Over 25 damaging floods have occurred in the Lahaina area since 1879. These floods have caused damage to residential properties and commercial operations. Lahaina is listed as a historic district in the National Register of Historic Places.

The local sponsors of the project are the West Maui Soil and Water Conservation District and the County of Maui. Before the sponsors submitted a formal application for planning assistance, preliminary studies were conducted by SCS to determine if the watershed would qualify for PL-566 assistance. The studies identified the watershed problems, environmental concerns, and six alternative plans to alleviate the problems. The study findings are contained in the Lahaina Watershed Preapplication Assistance Report.

The formal application for federal assistance was submitted to and approved by the Department of Land and Natural Resources, the State Clearinghouse for water resource projects, in September 1981.

Additional information was gathered by SCS as part of the post-application phase of planning. Because of the concern of outletting storm waters into the coastal waters, Dr. Richard W. Grigg, Associate Marine Biologist, University of Hawaii, was contracted to conduct a benthic survey of the nearshore environment. A report entitled "Assessment of Potential Marine Ecological Impacts of the Lahaina Watershed Project", was prepared. The report recommended the Kauaula Stream mouth as the outlet area that would least be impacted by storm runoff.

The watershed's land and water resource problems were studied in greater detail, and recent changes in land use plans for Lahaina were considered. New information gathered in this post-application phase necessitated an evaluation to determine whether acceptable alternative plans could be developed and PL-566 assistance provided. The six alternatives were reevaluated and five of the plans were found to be unacceptable because of economic feasibility, environmental concerns, or other findings. One alternative was found to be acceptable. A preauthorization report for the Lahaina Watershed was prepared and a request for planning authorization was submitted to National Headquarters. Planning was authorized on March 18, 1985.

Federal, State, and County agencies were informed of the planning start and asked to provide any information or concerns they may have on the watershed area. Information was provided by the following: State Historic Preservation Officer, State Division of State Parks, State Department of Land & Natural Resources, U.S. Fish & Wildlife Service, State Division of Forestry and Wildlife.

During project planning two basic configurations were formulated. One configuration used Kauaula Stream as the sole outlet. The other used

Kauaula Stream in conjunction with a secondary outlet to the south of Puamana Park.

Formulation of an alternative that would divert a portion of the storm water in Kauaula Stream south to second outlet necessitated a supplemental reconnaissance marine assessment of the Puamana outlet area. Dr. Grigg was contracted to do the supplemental work. A site south of Puamana Park was identified as the best outlet because it is the poorest reef area. The Kauaula Stream outlet was the second choice. After analyzing the alternatives, the singular outlet at Kauaula Stream was selected because environmental impacts were not significantly increased by using the singular outlet and because it afforded considerable cost savings.

The evaluation of sediment discharge from the Lahaina Subwatershed and the Kauaula Subwatershed was a major item of work during planning. The reduction of fine sediment entering the nearshore waters fronting Lahaina Town and the coarse sediment yield from the Kauaula Subwatershed were quantified using varied data and sediment transport relationships. The SCS Sedimentation Geologist, Dr. Frank Reckendorf, from the West National Technical Center assisted the Hawaii staff with quantification of the sediment yield values

During evaluation of these alternatives, meetings were held with the State Department of Transportation to coordinate the Lahaina By-Pass road alignment with the project. The Planning Staff also met with AMFAC Properties to discuss the development plans AMFAC, Inc. had for the area. The State Historic Preservation Office (SHPO) was asked to assist in conducting a reconnaissance archaeological survey of the proposed alignment of the floodwater diversion, sediment basin and the diversion alignment to the Puamana Park outlet. The survey concluded that "the proposed project will have no impact on any known cultural resource in the area". During the Section 106 consultation with the SHPO, there was concern about the five houses in Waine'e village that will be affected by the project. The houses, which are a part of the Pioneer Mill, Co. sugar plantation, are in the alignment corridor of the floodwater diversion and may need to be moved. Determination was made by SHPO that the five houses had little historic value.

The National Economic Development (NED) Plan was determined using incremental analysis of costs and benefits. A flood protection plan providing 50 year level of protection was selected as the NED Plan. A steep increase in costs required to reconstruct the Honoapiilani Highway bridge and the adjacent Pioneer Mill bridge made less feasible higher levels of flood protection.

Three public meetings were held in Lahaina during post-authorization planning of the project. The first meeting, in 1985, was for the purpose of gathering data and concerns from the public. The second meeting discussed the formulated alternatives and resulted in the selection of a community preferred alternative. The third meeting presented the recommended alternative.

There has been good community and sponsor support for this project. Publicity for the project has been good and so has the interest by private

organizations and individuals. The staff has had many meetings with the sponsors, Pioneer Mill, AMFAC Properties, and the State Department of Transportation. Meetings were also conducted with the Puamana subdivision community to keep them informed of planning progress. Kauaula Stream outlets through the Puamana subdivision.

INVESTIGATION AND ANALYSES

ECONOMICS

Introduction

The evaluation of benefits for the Lahaina Watershed Project measures the benefical contributions to national economic development (NED) associated with flood hazard reduction. The project improvements contribute to the NED objective by improving the net productivity of flood prone land resources. This occurs either by an increase in output of goods and services and/or by reducing the cost of using the land resources. Evaluated conditions include potential land use changes, additional development, and similar modifications which will alter the hydrologic response and potential economic damages. The benefit analysis involves analyzing interrelationship between hydrologic, hydraulic and economic characteristics of the floodplain in accordance with standard SCS procedures. Procedures are in accordance with The Economics and Environmental Principles and Guidelines for Water and Related Land Resources Studies issued by the Water Resources Council on March 10, 1983.

The principal benefits for flood control facilities are inundation reduction benefits. These "benefits" are the loss in income to the nation as a result of flooding commonly measured as the physical damages, business losses, and emergency costs. The inundation reduction benefit is the value of reducing flood losses to activities which would use the floodplain without any plan. It is measured as the reduction in the amount of damages or related costs. The economic life of the project evaluated is fifty (50) years. This period is consistent with projects of this scope and type. The discount rate for current FY 1990 Federal water resources projects is 8 7/8 percent. All benefits and costs are evaluated in constant 1990 dollars and extrapolated to the base year.

Project Costs

The total installation costs include the first construction cost, contingency, indirect costs, relocation costs, and rights-of-way costs. To obtain the annualized installation costs the sum total is adjusted to present value then amortized over a 50 year economic life at the specified discount rate. Added to the annualized first cost is the annualized operation, maintenance, and replacement (OM&R) costs. The sum is the annualized project cost, which is compared to corresponding benefit values.

Project Benefits

The benefits of flood hazard reduction were determined by computing the difference in average annual flood damages with and without the project. The average annual flood damage analysis include the evaluation of damages to agricultural and existing commercial and residential development in the floodplain, upgrading of the contents of residential, and emergency costs. Data used in the evaluation of flood damages and benefits were obtained from field investigations of agricultural, residential, commercial, and public properties. For the evaluation, benefits were derived for each

subwatershed area: Lahaina Subwatershed-North, Lahaina Subwatershed-South, and Kauaula Subwatershed.

Unit Damages

Buildings in the floodplain are primarily wood frame structures, constructed on post or concrete slab. However, some concrete block structures are found in the lower reaches of the floodplain. In computing the estimated damages to residential development, water surface elevations in the floodplain area were first determined for various flood magnitudes using data from past floods as a reference. The depth of flooding and the estimated damages were then determined by correlating the floor elevations and the depth-damage curves for type of structures, commercial contents (inventory), and residential contents were developed for the area. The depth-damage curve was adjusted to reflect conditions in the floodplain. The value of each structure in the floodplain were obtained from the State of Hawaii Department of Taxation.

Computations were made using the SCS derived URB I computer program revised 11/09/86. Currently there are 279 homes, 3 condominiums, and 2 hotels in the floodplain. The 239 commercial or public establishments occupy 69 building structures in the Lahaina Watershed Floodplain within the Lahaina community. Of the above totals, 184 residences and 134 commercial businesses receive flooding. To maintain the character of the Lahaina Historic District all new buildings and remodeling work are wooden structures on concrete slab. Every establishment was identified under the Standard Industrial Classification nomenclature (SIC) system with categories listed on Table 1. One existing major industrial establishment is affected by flooding. Value of contents for each establishment was estimated from field interviews including cost of probable damage at varying stages of flooding, and depreciated accordingly. When available historical damages experienced were included. Structural values for all commercial and residential buildings were available from public records.

In computing the estimated damages to commercial developments, water surface elevations and floodplain area were first determined for various flood magnitudes. The depth of flooding and estimated content damages for each commercial establishment were furnished by each establishment. Estimated damages to structures were determined by correlating the floor elevation and the depth percent damage curves for each type of structure. These curves were developed by the Hawaii District of the Corps of Engineers for the Kahoma Flood Control Project using damage data from flood insurance reports and adjusted using records of past floods from field interviews in Lahaina community to reflect conditions of the floodplain. The Kahoma Watershed is located west and adjacent to the Lahaina Watershed. Much of the new commercial development in the greater Lahaina community is currently occurring in the Kahoma Watershed.

Value of contents for each establishment was estimated from field interviews including estimated cost of probable damage at varying stages of flooding. When available historical damages experienced were included. Market values for all buildings affected by flooding were obtained from public records. These commercial buildings currently have a total structural value of about $ 14 million.

In computing damages to commercial development, water surface elevations and the flood plain area were first determined for various flood magnitudes. The depth of flooding and estimated content damages for each commercial establishment were determined by correlating the floor elevations and the depth-damage data calculated for each type of commercial enterprise . Each depth-damage curve is identified by Standard Industry Codes (SIC) for each type of commercial enterprise. Estimated damages to structures were determined by correlating the floor elevation and the depth percent damage curves developed for each type of structure. Most of the commercial structures consisted to wood structures on concrete slab.

For purposes of evaluating content and structural damage to urban development, the still water condition was used because of low velocity flood flows and flat slopes in the urban area. Depth damage curves developed by the Corp of Engineers for the Kahoma Flood Control Project in the Lahaina District were used. These curves were adjusted with information from flood insurance reports and records of past floods from interviews in Lahaina Watershed to relect conditions of the floodplain. Most of the commercial firms in the Lahaina floodplain are located in the Lahaina North Subwatershed, while the residential areas are concentrated in the Lahaina South Subwatershed and Kauaula Subwatershed.

Approximately 80 acres of sugarcane land is susceptable to overland flooding. However, only 64 acres will be protected. Normally, sugarcane is a two (2) year crop in that section of the watershed. During the first seven to nine months of growth the fields are prone to erosion, sedimentation, and damage to irrigation systems. Some minor damages to plantation roads is also sustained. However, the plantation has minimized flood damages by scheduling harvesting of fields susceptible to flooding during the early summer months which are characterized by low rainfall. Damages are further minimized by the maintenance of existing land treatment measures as soon as the sugarcane crop is harvested. Therefore, agricultural damages are generally low because of excellent field crop management. A damage frequency analysis was used to determine average annual damages.

Public agency damages or emergency costs are based on analysis of operation during the past floods. They include expenditures for County emergency crew, Red Cross relief work, County, State, and Federal investigation teams, police, and rescue crews. Also included are living away from home expenses for the flood victimes and loss of income for the duration of the cleaning and restoration operation. The damage frequency analysis was used to determine average annual damages. Emergency costs spent by County crews represented the bulk of expenses expended by all public and relief agencies. These costs consisted of clean-up and pumping water out of residences located in low lying areas.

TABLE 1

SIC CODES USED IN THE LAHAINA COMMERCIAL SECTOR

SIC CODE	INDUSTRY - BUSINESS
	Manufacturing
391	Jewelry, silver, plated ware
	Wholesale Trade
504	Sporting Goods, toys, hobby
514	Groceries & related products
518	Beer, wine, distilled beverages
	Services
739	Miscellaneous business services
	Retail Trade
541	Grocery stores
553	Auto & home supply stores
554	Gasoline service stations
561	Men, boys, clothing, furnishing
562	Women ready-to-wear stores
563	Women accessory & speciality store
564	Children, infant wear store
565	Family clothing store
566	Shoe store
569	Miscellaneous apparel & accessories
573	Radio, TV stores
580	Eating and drinking places
591	Drug store & propriety store
594	Miscellaneous shopping good store
597	Jewelry retail
599	Miscellaneous retail stores, other

Discharge-Damage Computation

Water surface elevations were determnied for various magnitudes of floods by reach in analyzing probable damages. Length of reach was limited by maximum grade change of one foot. A discharge damage relationship was determined by correlating the various flood stages and number of businesses and residences affected by their first floor elevation. Tangible damages were totalled and plotted against the corresponding discharge.

Damage Frequency Computation

The damage frequency information was derived by use of the URB-1 Computer Program. Total average annual equivalent damages are estimated to be $195,620 (Residential), $389,700 (Commercial), $10,700 (Agriculture), and $4,180 (Public Property). Floodproofing costs are estimated at $71,530. Red Water Pollution damages to the Resort Industry is estimated at $107,910. With the proposed improvements, the residual annual damages are estimated to be $19,190 (Residential) and $30,700 (Commercial). Average annual agricultural and public agency damages were calculated by using the historical method which analyzed three major storms of record. Based on the Lahaina Community Development Plan, sugar cane land acreage in the floodplain will maintained as a green belt.

Flood Reduction

According to Maui County Ordinance 1145, floodproofing is a requirement for all construction within the Lahaina Watershed floodplain up to and including the 100-year flood limit as delineated by the "final flood insurance rate map 1 June 1981". Lahaina has not experienced any appreciable decline in tourist activity and property values have continued their spiral particularly with the influx of foreign Japanese investment capital. Housing continues to be a critical issue despite major strides by the tourist industry to provide housing and development capital to develop the necessary infrastructure.

Despite the threat of rising interest rates, construction costs have continued to follow the upward spiral of property values. While all business-commercial and business-residential (apartment-hotel) properties are expected to be floodproofed, there is expected to be considerable resistance to develop vacant single family residential lots in the flood plain. Periodic monitoring has affirmed this.

Total available land area in the flood plain zoned for business-commercial and business-residential (apartment-hotel) that is subject to the flood plain ordinance is approximately 31 acres. Of this total land area thirty (30) percent or approximately 10 acres will dedicated to parking and landscaped areas.

Intangible benefits which would accrue from the recommended project are the reduction of health hazards associated with floods, and the improved morale of residents of the floodplain as result of the reduction in flood damages and, in the case of the Kauaula Subwatershed, threat to life and limb.

Future Development

Since the mid-1930's, there has been a steady upward trend in per capita personal income and personal consumption expenditures. This constant increase measures the growing affluence of people and is reflected in the continuous upgrading of consumption items including living quarters and pesonal possessions. In computing flood damages to existing development, the future increase in damageable property must be considered to reflect reasonable treatment of what damages would occur. The following rationale and data were used in developing future flood damage reduction benefits:

a. In consideration of the Maui County Flood Plain and Tsunami Inundation Area Ordinance and the Flood Disaster Protection Act of 1973, no new development is anticipated in the flood plain without adequate flood proofing. The existing number of residential homes and commercial structures can be expected to increase slowly until the watershed project is installed. All new construction until then is required to be flood proofed.

b. The per capita income, as published in the 1988 Department of Business and Economic Development (DBED) State of Hawaii, Population and Economic Projections for Maui County: 1985 to 2010 was used to project future residential damages and is shown on Table 5.

c. The average value of residential structures and contents are $32,220 and $12,491 respectively.

d. The existing average annual content damage is $52,325.

Per capita income is projected to increase from $11,938 in 1989 to $22,987 in 2060 (In 1982 Dollars) (Table 2). Assuming that the value of contents would increase to a maximum of 75 percent of the value of a structure or $24,165, based on present average value of residential structures in the floodplain, the maximum value would be reached by the year 2060. Using procedures outlined in section 2.4.11 of the Economic and Environmental Principles and Guidelines, the average annual damage resulting from application of the affluence factor methodology to existing residential development is $18,610. Per Capita Income Factor was calculated at 1.11.

Business and Financial Losses

Benefits from prevention of business and financial losses are not expected to accrue from the project. Increased business activity outside the flood plain limits would offset any losses thet may occur to flooded commercial enterprises.

TABLE 2

PROJECTED PER CAPITA INCOME

Year	Projected DBED Per Capita Income	Percent Increase Base Year 1989 to 2060	Projected Content Value
1976	$ 6,239		
1977	6,842		
1978	7,589		
1979	8,329		
1980	9,141		
1981	9,778		
1982	10,562		
1983	10,968		
1985	11,100		
1989	11,938		12,491
1990	12,400		13,497
1995	13,400		14,455
2000	14,300		15,065
2005	14,900		15,671
2010	15,500		16,300
2015	16,123		16,956
2020	16,771		17,638
2025	17,445		18,346
2030	18,147		19,084
2035	18,576		19,851
2040	19,635		20,649
2045	20,424		21,479
2050	21,245		22,343
2055	22,099		23,241
2060	22,987	93.5	24,175

Summary of Benefits

The fifty (50) year level of protection was selected as the NED project. The average annual benefits from prevention of flood damages to residential, commercial, agriculture, and public facilities is estimated at $176,430 (residential), $359,000 (commercial), $51,730 (reduction of floodproofing), $9,630 (agriculture), and $3,800 (pubilic property). With the proposed improvements, residual damges of $19,190 (residential), $30,700 (commercial), and $38,720 (red water) is expected to occur annually. Annual floodproofing costs of $19,800 is expected to continue in unprotected areas. Three (3) levels of protection twenty seven (27) year, fifty (50) year, and one hundred (100) year were analyzed to determine the most efficient level of protection. Due to economic efficiency, it was determined that the fifty year level of protection would the National Economic Development (NED) project.

INVESTIGATION AND ANALYSES

GEOLOGY

Introduction

An investigation of the foundation conditions along the alignment of the proposed Lahaina Watershed diversion was conducted during the period of March 17-19, 1986. Sediment discharge from the Lahaina and Kauaula subwatersheds was examined and sediment yield estimates were made for with project and without project conditions.

Location

The Lahaina Watershed is 4,920 acres in size and is located on the northwest side of the Island of Maui. (See location map). The watershed has a very steep rainfall gradient. Average annual rainfall ranges from 15 inches along the coastline to 300 inches in the mountains, located 4 miles inland. Average annual temperature is 75 degrees F.

Of the 4,920 acres, 440 acres are in urban uses such as residential and commerical; 1,080 acres are used for agricultural purposes, primarily sugarcane production; and 3,400 acres are forest and brushland. The major urban area is located along the coastline and is a part of Lahaina town. Sugarcane dominates the landscape from elevation 40 to 1,400 feet. The upper watershed area is forest and brushland.

Geological Setting

Maui is the second largest island in the Hawaiian chain. It was formed by two volcanic mountains, East and West Maui mountains.

East Maui, or Haleakala volcano, is 10,025 feet high and 33 miles across. West Maui is 5,788 feet high and 18 miles across.

The Lahaina watershed is located in West Maui. The West Maui mountains are incised by deep amphitheater-headed valleys. Kauaula Stream, a major drainageway in the watershed, occupies one of these valleys. The volcano is the "central type" in contrast to the "fissure type", because dikes radiate in all directions from the ancient caldera and almost all the lava beds are steep and many were poured from the central vent. Typically, the lava flows are thin-bedded a'a and pahoehoe.

The volcanic rocks of West Maui are divided into three series. The oldest is the Wailuku volcanic series - basaltic flows that built the volcano. The Honolua volcanics, consisting of thin andesitic and trachytic flows, covers the Wailuku volcanics. After a period of quiescence, eruptions produced the Lahaina volcanic series.

The major geologic units in the watershed consists of the Wailuku and Honolua volcanic series, sediments of consolidated earthy deposits, and sediments of unconsolidated deposits.

Foundation Investigation

Structural Data

The proposed structural measures consists of diversion channels, sediment basins, a debris basin, and an outlet channel. The proposed plan includes a .2 mile long, 10 feet wide, high velocity, reinforced concrete channel to extend from an inlet basin along Lahainaluna Road at elevation 125 feet to a stilling basin at the upper end of an earth diversion channel at elevation 75 feet. The 1.27 mile long earth diversion will have a trapezoidal cross-section of 2:1 side slopes and bottom width that varies from 15 feet to 25 feet. Three sediment basins will be constructed along the diversion by widening the channel width to 75 feet to 125 feet and lowering the channel bottom by 2 to 3 feet.

The diverted runoff from the Lahaina subwatershed will be combined with discharge from the Kauaula subwatershed at an embanked and excavated debris basin located on Kauaula Stream, 200 to 600 feet upstream from Honoapiilani Highway.

Exploration

The purpose of the investigation was to determine the subsurface conditions along the alignment of the proposed diversion. A backhoe was used to excavate 17 test pits, that ranged in depth from 1.5 to 10 feet. Soil samples were obtained for testing.

The surface material generally consists of clay, CL. Below the clay are deposits of boulders or "older alluvium". The older alluvium consists of mottled brown to red-brown deeply weathered, poorly sorted, nearly impermeable friable conglomerates.

The subsurface conditions can be separated into three types: lava flows, older alluvium, and river run boulders and cobbles.

Conclusion

The subsurface conditions along the floodwater diversion alignment can be separated into three types: lava flows, older alluvium, and river run boulders and cobbles. All of the subsurface material along the alignment can be excavated using standard excavation equipment.

There is an abundance of coarse material in the subsurface making the channel stable under design flow conditions. The initial flows will carry the fines and in time a bed armor will form in the sections of river run material.

Since there will be a substantial amount of cobbles and small boulders excavated, the embankments should make use of this available material.

The subsurface conditions at the Kauaula Stream debris basin site consists mainly of large boulders and cobbles. The foundation is strong enough to support the proposed embankment. There may be a problem in storing or disposing of the large boulders.

Sediment Yield Investigation

Quantification of sediment yield from the two subwatersheds was necessary for design of the sediment basins along the diversion and of the debris basin on Kauaula Stream. Sediment yield analysis was also needed to establish the reduction of sediment to the Lahaina Town nearshore area.

The Modified Uniform Soil Loss Equation was used to evaluate sediment yield by storm event for the Lahaina Subwatershed. The form of the equation used is: S = 95*((Q*qp)**0.56)*K*L*S*C*P. The subwatershed was divided into seven subareas along the slope separated by existing ditches or field roads. The average annual sediment yield varied from 20 tons/acre in the steepest sub area to less than 2 tons/acre in the flattest subarea. A 30 percent delivery ratio was used resulting in an average annual sediment yield of 3,800 tons per year. Soils tests indicate that roughly 25% of the sediment, by weight, will be larger than 3 mm in diameter.

Additional studies correlating Lahaina subwatershed sediment discharge to that from sugarcane fields in Waialua, Oahu and Kamooalii Watershed, Oahu resulted in yield by storm event.

Storm Recurrance Interval	Tons per Event
100 years	10,000
50 years	7,500
25 years	5,500
10 years	3,500
5 years	1,700
2 years	1,000

Coarse sediment yield from Kauaula Stream was estimated to size the debris basin. It was assumed that an inexhaustible sediment supply existed in the upper watershed and that yield was limited only by transport capability of the channel. A yield vs. storm frequency relationship was developed using tractive force-boulder size analysis and using other empirical relationships. Estimated sediment discharge rates were compared to known discharge rates of Moanalua Stream and Kamooalii Stream.

The bedload discharge rates by storm recurrance are as follows for Kauaula Stream.

Storm Recurrance Interval	Tons per Event
100 years	7,0000
50 years	5,000
25 years	3,200
10 years	2,000

Sediment budgets for Average Annual and 50-Year Storm condition, with and without project implementation, are shown in Table 3.

TABLE 3

SEDIMENT BUDGET
(TONS)

		LAHAINA SUBWATERSHED				KAUAULA SUBWATERSHED			
		LAHAINA YIELD	DEPOSITION FLOODPLAIN	DEPOSITION SED. BASIN	LAHAINA OCEAN DISCHARGE	KAUAULA YIELD	DEPOSITION DEB. BASIN	KAUAULA OCEAN DISCHARGE	TOTAL OCEAN DISCHARGE
W/O PROJECT	FINE SED.	3,800	400	--	3,400	600	--	600	4,000
AVG. ANNUAL	BEDLOAD	0	0	--	0	550	--	550	550
	TOTAL SED.	3,800	400	--	3,400	1,150	--	1,150	4,550
W/PROJECT	FINE SED.	3,800	10	1,320	30	600	210	2,830	2,860
AVG. ANNUAL	BEDLOAD	0	0	0	0	550	550	0	0
	TOTAL SED.	3,800	10	1,320	30	1,150	760	2,830	2,860
W/O PROJECT	FINE SED.	7,500	800	--	6,700	8,400	--	8,400	15,100
50 YEAR	BEDLOAD	0	0	--	0	5,000	--	5,000	5,000
	TOTAL SED.	7,500	800	--	6,700	13,400	--	13,400	20,100
W/PROJECT	FINE SED.	7,500	800	2,250	0	8,400	2,520	11,130	11,130
50 YEAR	BEDLOAD	0	0	--	0	5,000	4,900	100	100
	TOTAL SED.	7,500	800	2,250	0	13,400	7,420	11,230	11,230

INVESTIGATION AND ANALYSES

HYDROLOGY

Introduction

The hydrologic investigation for the Lahaina Watershed involved determination of peak runoff discharges and water surface profiles that were used to design structural measures and evaluate flood benefits. Peak discharges and water surface profiles were determined using conventional SCS hydrology and hydraulic computer models. The validity of the hydrology model was justified by utilizing it on nearby watersheds that are gaged. The water surface model was correlated to known highwater marks within Lahaina.

The Lahaina Watershed, typical of most small watersheds in the islands, has steep upland slopes that run into the flat coastal plains. Land use in the watershed range from agricultural (sugarcane) and conservation in the uplands and urban in the plains.

This watershed was subdivided into two subwatersheds, the Lahaina and Kauaula subwatersheds. Based on interviews with local residents in Lahaina, both of the subwatersheds was further divided into the north and south portions. The north portion of the Lahaina Subwatershed extends from just southerly of the Papalaua Street to Dickensen Street, while the south portion extends from Dickensen Street to Shaw Street. The north portion of the Kauaula Subwatershed extends northerly of the improved channel and the south portion extends southerly from the channel into the Pua Mana Subdivision.

The runoff from each of subwatersheds drains into the ocean. The Kauaula Subwatershed outlets to the ocean via an improved concrete lined trapezoidal channel and the Lahaina Subwatershed, with no defined outlet, drains through various areas in the commercial and residential areas of Lahaina town.

Methodology

Peak Discharge

The hydrology computer model used was the TR-20 program, which is based on SCS's NEH-4, Hydrology. This program required the following input paramters: curve number (CN), time of concentration, rainfall distribution, rainfall depth, and antecedent moisture condition.

The major landuse in the Lahaina Subwatershed is sugarcane, and a composite CN was developed based on the stages of growth since sugarcane is a two year crop and is constantly being harvested and planted throughout the subwatershed. This composite CN was used in the both subwatersheds, along with CN values for residential, open space, pasture, industrial, brush land, and Ohia-Koa forest type found in NEH-4 and the Hawaii Forest Type

Legend. The Soil Survey for the Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii was used to determine soil series and their respective hydrologic properties.

Standard Type-I rainfall distribution with an antecedent moisture condition II was used to determine peak discharges. Actual rainfall data was also used to try to develop synthetic hydrographs in the Kahoma Watershed in order to check the validity of the TR-20 program. However, the results were inconclusive. The 24-hour rainfall depths for various frequency storms were extrapolated from rainfall maps in Technical Paper No. 43. Time of concentration for each stream within the subwatersheds was computed from the velocities read from charts of figure 15.2 fo NEH-4.

The validity of the SCS TR-20 model was tested on the two streams that are presently being gaged. Input parameters for watersheds of these two streams were used in the model to predict peak discharges for various storm frequencies. A discharge-frequency curve for each stream was plotted and compared with Water Resources Council (WRC) discharge-frequency curve estimated from gaged data and it was found that the results were divergent. However, adjustments to the CN, the frequency curves generated by the model was made parallel to the WRC frequency curves. These adjustments were then applied to the models for the Lahaina and Kauaula subwatershed. Further, discharge per square mile for these subwatersheds was also compared to the the values for the gaged data of Kahoma Stream and were found to be comparable.

Water Surface Profile

The WSP-2 computer program was the hydraulic model used to generate water surface profiles for the economic evaluation of alternatives. Water surface profiles were developed for both the north and south portions of Lahaina and Kauaula subwatersheds. The input parameters to this program were cross-sectional data for the drainages, surface roughness, and stream lenghts.

Cross-sections were developed from a aerial photo topographic map that had a scale of 1" = 200' and a contour intervals of 1 and 2-feet. Surface roughness (Manning's "n') was adjusted such that the water surfaces matched high water marks of known storms. In the urban areas the "n" was equal to about .20. The storm of January 1982 was used as the storm of record. The stream reach lenghts were read off the topographic maps.

URB1 (Economics Data)

In order to determine flood benefits the stage/discharge data and peak discharges from the WSP-2 and TR-20 model along with data from the economist were used in the URB1 program to develop the annual average flood damages for the various alternatives.

To account for the existing storm drain systems within Lahaina Subwatershed, it was assumed that these systems would be able to handle up to a 5-year frequency storm in the Front Street area. All other areas were assumed to have negligible benefit from existing drainage systems due to the flat slopes and possible plugging of drains.

Hydrologic and Hydraulic Assumptions

The following were the assumptions that were the basis of the hydrologic and hydraulic analysis:

1. The Lahaina Watershed was split into two subwatersheds: Lahaina and Kauaula. Each of these subwatersheds were further split into their respective north and south portions. This was based on interviews with local people, Pioneer Mill people and topographic maps. The crux of these interviews indicated that Dickenson Street was the dividing line for the north and south portion of the Lahaina Subwatershed and Kauaula Stream was used as the dividing line for the Kauaula Subwatershed.

2. Kauaula Stream, within the Kauaula Subwatershed has only limited capacity (< 10 year frequency). A WSP2 run was used to determine the most critical section where the stream would overtop. Due to the difficulty in determining where the overtopping water would go, it was assumed that 50% of the water that overtops would go to the north and 50% would go to the south. These flows were then routed through the Pua Mana Subdivision. Side boards were assumed based on aerial top survey.

3. "n" values used in the urban areas were adjusted in the WSP-2 runs to fit known high water marks for the January 21, 1982 storm.

4. Existing storm drain systems within the commercial area of Lahaina town were assumed to have capacity of handling up to a 5 year storm. All other systems were not considered as having any capacity.

5. Within the Kauaula Subwatershed, the discharge-frequency relationships were adjusted by reducing CN values to fit the WRC Bulletin 17B assuming station skew (with adjustment for historical data) for the gage on Kauaula Stream (#16643300). CN values for the Lahaina Subwatershed weren't reduced because the sugarcane fields are irrigated most of the time and the soils are probably saturated to some extent.

6. Estimates for CN values of sugarcane (furrow and drip) were weighted according to the length of crop stage. CN for brushland and forest were developed using the forest service maps that detailed the different forest types in Hawaii. CN for residential and commercial were based on values in NEH-4.

7. "R" values to determine velocity for Tc determination were estimated from cross-sections taken off the quad sheets. Velocities were either read from Fig 15.2 of NEH-4 or estimated from WSP-2 runs.

INVESTIGATION AND ANALYSES

ENGINEERING

General

The engineering analysis for the Lahaina Watershed consisted of evaluating alternatives for providing flood protection to the commercial, residential, and agricultural areas in the watershed that are damaged by frequent flooding. The alternative plans were based on a diversion of the problem runoff to an ocean outlet. The major components of the investigation are as follows.

1. A hydrologic analysis was conducted to obtain storm frequency vs. runoff relationships for the Lahaina and Kauaula subwatersheds.

2. Nonstructural and structural measures were evaluated for effectiveness in solving the identified problems.

3. A diversion channel was designed to intercept the runoff from the Lahaina subwatershed upstream of present or proposed development. Allowable flow velocities for the vegetated earth channel were established. Sediment discharge rates were estimated for sediment basin design. The diversion channel was located with the objective of minimizing installation costs while maximizing the benefitted area.

4. Ocean outlet alternatives were evaluated with respect to installation cost, environmental effects, and effects to cultural resources. The Kauaula Stream outlet was determined to be the most appropriate ocean outlet. The existing bridges limit the discharge capacity of the outlet. Evaluation of reconstructing the Kauaula outlet was conducted.

   A debris basin on Kauaula Stream to prevent damaging coarse sediment from entering the improved outlet was designed following a sediment yield analysis of Kauaula Stream.

5. Four alternatives, offering three levels of protection, were evaluated. The installation cost for each was developed by determining work item quantities for the structural improvements. Operation, replacement, and maintenance requirements were also estimated for each alternative.

Solutions to the Flooding Problem

Land Treatment

Intensified land treatment measures on the sugar cane fields were considered in order to decrease runoff and reduce soil erosion. The ongoing conservation program by Pioneer Mill with assistance from the SCS and the West Maui SWCD was thought to provide the necessary land treatment. Additional land treatment efforts would not appreciably reduce runoff or sediment discharge volumes.

Nonstructural Measures

Nonstructural measures to decrease flood and flood related damage were considered. Nonstructural measures are intended to modify the impacts of flooding rather than modifying the flood itself. The nonstructural measures considered are described below.

Zoning of the floodplain to restrict its further development was examined. The fact that zoning regulations would not prevent damage to existing development and public resistance to development restriction in the primary commercial district dropped this measure from further consideration.

The acquisition of vacant parcels and the removal of flood prone homes were considered but was found to be cost prohibitive. Residential properties in the floodplain area have sold recently for as much as $430 per square foot.

Floodproofing of public and commercial buildings was investigated. This included elevating structures, building perimeter walls around properties, building protective walls around structures, and applying sealants. The density of development in Lahaina Town and the age of many of the structures makes the installation of floodproofing measures difficult. The lack of an adequate flood warning period also limits the practicality of many floodproofing measures.

A system of flood forecasting, warning, and evacuation was considered ineffective in the Lahaina situation due to the flashy nature of flooding in Hawaii.

Structural Measures

A cursory search for a floodwater detention reservoir site was made for the Lahaina subwatershed. For the Lahaina subwatershed, a detention volume on the order of 50 million gallons was needed. A properly located site with adequate storage volume was not found and the detention reservoir measure was dropped from further consideration.

The flooding in Lahaina is a result of runoff conveyed through numerous small drainages spread along the width of the Lahaina subwatershed. For this reason, a diversion channel to intercept the runoff from the Lahaina subwatershed and carry it to a safe outlet appeared to be the most practicable solution to the flooding problem. Frequency vs. discharge relationships were developed for the Lahaina and Kauaula subwatersheds by the Hawaii hydrologist using the SCS TR-20 computer program.

A diversion channel extending across the Lahaina subwatershed from Lahainaluna Road to Kauaula Stream was planned. Most of the diversion channel will be vegetated earth channel. Channel stability was determined using the procedure discussed in USDA-ARS, Stability Design of Grass-Lined Open Channels.

Several outlet locations were considered for the diversion channel. The the completion of design and the commencement of construction of a flood control project on Kahoma Stream, to the north, precluded its use to outlet the additional runoff from the Lahaina subwatershed. Ocean outlets at the

end of Dickenson Street and at Maluuluolele park between Prison Street and Shaw Street with covered concrete channels were proposed. High construction costs and environmental concerns regarding sediment discharge into the fringing reef area fronting Lahaina town diminished their practicability.

Kauaula Stream, to the south, presented many advantages as an outlet for the diversion channel. The Kauaula subwatershed peak discharge is nearly four times greater than the discharge from the Lahaina subwatershed for the same frequency storm. Kauaula Stream capacity and its ocean outlet have been naturally developed to accommodate high runoff and high sediment concentrations. In addition, the Kauaula subwatershed is considerably greater in length than the Lahaina subwatershed resulting in a lag between the peak discharges from the two subwatersheds. For the same storm, the peak discharge from the Lahaina subwatershed will pass well before the peak discharge from the Kauaula subwatershed. The discharge from the diversion channel is not expected to increase the the peak discharge in Kauaula Stream more than 2%.

The primary earth diversion channel was set below the general slope break at the 80 foot to 100 foot MSL elevation to minimize the volume of excavation and embankment fill. The highest alignment below the slope break was selected to provide flood protection to the development proposed by AMFAC above Honoapiilani Highway. The slope of the diversion channel has been set to minimize the right of way needs while maintaining earth channel stability.

The channel alignment is further constrained by Pioneer Mill's Wainee Reservoir. The channel has been kept below the toe of the reservoir embankment while minimizing its effect on the households in Wainee Village. Five households in Wainee Village may be affected by diversion installation.

The diversion will be lined with bermudagrass. Stability analysis was conducted in accordance with USDA-ARS, Stability Design of Grass-Lined Open Channels. A noncohesive soil was assumed to account for the large fraction of coarse material. The iterative analysis indicates channel stability given a D75 soil particle size greater than 1" diameter.

At the upstream end of the earth diversion a reinforced concrete U-frame channel is used because of the steep gradient (4%). An earth inlet basin along side Lahainaluna road will collect the roadside runoff and the discharge from the 2' diameter culvert from the subdivision to the north of the road. The inlet basin will also trap debris. A side inlet weir from the inlet basin will be used at the upstream end of the concrete channel. Side inlets to allow surface runoff to enter the channel along the uphill side of the channel will be provided.

A St. Anthony Falls stilling basin will be installed at the downstream end of the reinforced concrete channel. Tailwater will be provided by a sediment basin.

Three sediment basins will be installed along the earth channel. The basins will be widened sections of channel with inverts set two feet below

normal channel grade to provide sediment storage. Velocities will be limited to 2 feet per second at full sediment capacity. Sediment particles and aggregates larger than 3 mm will be trapped by the sediment basins. Preliminary soils analysis shows that roughly one-quarter of the surface soil particles are larger than 3 mm. Trap efficiency of 25 percent is assumed at design flows although it may be higher due to the lower velocities that will exist when the sediment pools are empty. The 50-yr sediment discharge is estimated to be 7,500 tons of which 1,875 tons will be retained. The average annual sediment discharge of the Lahaina subwatershed is estimated to be 3,800 tons. Storage capacity of 2,450 cubic yards exists in the three basins. One cubic yard of fine sediment is assumed to weigh one ton. A more detailed surface soil analysis will be conducted prior to design to ascertain sediment volumes.

The uppermost sediment basin will be 200 feet in length and 75 feet wide at the bottom. This basin is situated at the upstream end of the earth diversion and provides a stilling pool for the SAF basin. The middle basin is placed at the natural draw north of Wainee Village and will be a triangular 100 feet by 100 feet shape. The basin will be able to trap the larger cobbles and boulders that will be transported by high concentrated flows. The lower basin is situated just upstream of the debris basin. The basin is roughly 200 feet by 80 feet.

The existing Kauaula outlet is a 795-foot trapezoidal concrete-rock-masonry channel from the ocean outlet to the Honoapiilani Highway bridge. A rectangular reinforced concrete channel extends another 135 feet to the natural channel. The Front Street bridge is built over the trapezoidal section. The Honoapiilani Highway bridge and the Pioneer Mill cane haul road bridge span the rectanglar channel.

Two major discharge constraints of the existing outlet channel influence the level of protection and the total cost of the Lahaina watershed project.

The first constraint is the channel capacity at the upstream end of the Honoapiilani Highway bridge. The distance from channel invert to lower bridge chord is 7.5 feet. Subtracting a one foot freeboard the flow opening will be 6.5 feet by 25 feet. Assuming a maximum flow velocity of 40 fps, the channel, at this point, has a capacity of only 6,500 cfs which is far less than the 100-year discharge of 8,100 cfs. If a 100-year discharge capacity is desired the two remedies would be to reconstruct the channel or bridges to provide greater capacity or to route the excess discharge to a second outlet. Both approaches have been investigated and have been developed as Preliminary Alternative 1 and Preliminary Alternative 4, respectively.

The second constraint is the limited discharge capacity of the trapezoidal discharge channel and the doubtful structural integity of the CRM lining under high flow conditions. The channel was constructed in 1969 with a capacity of 4,500 cfs. The assumed average roughness coefficient was n = .025. The CRM channel sidewalls have sustained scour damage in past storms apparently due to high flow velocities and debris impingement.

For the 50-year alternative a 6-inch thick concrete lining was initially proposed to increase channel capacity by decreasing the "n" value to .014 and to provide a lining less prone to scour and cavitation damage. However, the possibility of lining failure due to high flow velocities and the difficulty of containing superelevation of flows at the curves made more prudent the use of a rectangular reinforced concrete channel through the Puamana Subdivision. The outlet channel will have a four inches of concrete wear surface on the floor and two inches of wear surface on the sidewalls.

Measures will be taken to protect the steel reinforcing from the damaging effects of the marine environment. The reinforcing steel for channel sections affected by seawater will be epoxy-coated. Concrete cover over reinforcing will be six inches in for surfaces in contact with seawater. High density concrete is recommended

The rectangular channel will use the same alignment as the existing channel and will employ a splitter wall from the Front Street bridge to the ocean outlet to limit stream superelevation.

The channel will flare in the final 130 feet from a width of 25 feet to 50 feet. At the outlet, the design flow depth will be 3.2 feet, invert elevation will be -1.5 feet, velocity will be 38 feet per second, and the Froude number will be 3.80. As with most channel projects of this type in Hawaii, energy dissipation will be provided by the ocean backwater. Although loose bottom material consisting of boulders and cobble will be flushed from the stream mouth area during high flows, littoral currents and wave action will readily refill the outlet with boulders and cobbles. The native rock stream mouth floor is expected to be unaffected by channel discharge.

The 50-year dischage of Preliminary Alternative 2 is 5,915 cfs and will be accomodated by the existing bridges at Honoapiilani Highway, the cane road, and Front Street. Spillway hydraulic analysis indicates that 5,915 cfs is the greatest discharge that can be generated with one foot of freeboard under the highway bridge.

Preliminary Alternative 3 initally proposed the use of the existing outlet with no improvements made. The design discharge would be limited to 4,500 cfs which is the 27-year recurrence interval discharge. However, the high entrance velocity of flows from the debris basin and high maintenance requirements for the existing channel made replacement with a reinforced concrete channel prudent.

Where the projected diversion enters the Kauaula Stream channel a debris basin will be built to prevent damaging boulders and large cobbles from entering the concrete outlet works. The channel reach immediately upstream of the debris basin has an average slope of over 6%. Boulders, several feet in diameter, are transported during high flows.

Transport of boulders by the high gradient stream occurs during periods of heavy streamflow. The upper watershed supply of the coarse sediment is considered unlimited by the Sedimentation Geologist. Cultivation of the sugarcane fields unearths large stones that are pushed up against the

stream channel and often roll into the channel. Bedload transport functions were examined to develop a storm frequency vs. bedload discharge relationship for Kauaula Stream that could be used to determine the storage requirement of the basin. Relationships developed from sediment discharge records for Moanalua Stream on Oahu were also used.

The basin was designed to capture all stones larger than 6" in diameter. Storage for coarse sediment discharge from a 100-year, 24-hour storm plus five years of annual sediment discharge was desired. It was determined that velocities of five feet per second or less would allow settlement of stones larger than 6" diameter. It was determined from the transport analysis that 7,000 tons of coarse sediment would be discharged during a 100-year storm. The average annual bedload yield was estimated to be 550 tons with a density of 1.3 tons per cubic yard. Approximately 3,450 tons of fine sediment discharge annually to the debris basin was also estimated.

A partially excavated, partially embanked basin, 440 feet long and 360 feet wide, is proposed for Kauaula Stream. Because the basin is set on slope, it will require an embankment 23 feet high at its downstream end and excavation 20 feet deep at its upstream end. The embankment will have a 15-foot top width, 2:1 outside side slope, and 3:1 interior side slope. Its total storage capacity will be approximately 11,000 tons. The basin will be of "flow-through" design with no water storage capacity.

With a full sediment pool and at design discharges the average velocity through the basin will be approximately 2 fps. Average trap efficiencies of 98% of bedload and 30% of suspended sediment are expected for the 50-year design storm.

Due to the limited capacity of Kauaula Stream in the reach down the alluvial slope, inflow into the debris exceeding the design discharge is not expected. Although flow exceeding 12,000 cfs is expected from the West Maui mountains in the event of a 500-year storm, once released from the valley, floodwater will flow down the alluvial slope through a natural channel that has a capacity that varies between 4,000 and 10,000 cfs. Discharge exceeding channel capacity will flow overland as out of bank flow. Although some return flow to the channel will occur, instream discharge will, effectively, be equal to the capacity of the reach of channel with least conveyance above the basin. Therefore, we assume that only 4,000 cfs will be in Kauaula Stream entering the debris basin unless stream capacity is increased by improving the constricting reaches. The remaining 8,000 cfs of the 500-year discharge will inundate the coastal plain along a broad front.

A severe constriction of Kauaula Stream exists at the Lahaina Pump Ditch #2 bridge located approximately 1,000 feet upstream of the proposed debris basin. Present bridge capacity is about 2,000 cfs. The bridge is in need of repair due to erosion around the pier footing. We expect that the bridge will be rebuilt by the Pioneer Mill Company, at which time flow capacity can be increased. Much of the out of bank flow can be returned to the stream channel by grading the cane fields and roads.

Construction of the realigned Honoapiilani Highway will likely require the installation of a bridge over Kauaula Stream uphill of the debris basin.

Continued coordination with the State Department of Transportation can assure that design discharge to the basin can be maintained.

Although the basin is designed as a flow-through structure with no retention or storage pool, its location above the state highway and the Puamana subdivision makes it a class "C" structure. Dam breach discharge was estimated by the method in NEM 210-V, Circular No. 1 - Dam Breach Discharge Criteria. The breach discharge was estimated at 3600 cfs. Although an attenuated flood routing was not conducted, the wave front inundating the Puamana Subdivision from a catastrophic breach would be about a foot high, assuming a 400-foot wave front travelling at 10 feet per second.

Incremental analysis of costs and benefits indicates Preliminary Alternative 2 that provides 50-year protection maximized net benefits and is the National Economic Development plan. The NED plan is shown as Alternative 2 in the Plan/EA and was selected as the recommended plan.

Project Costs

Project cost estimates were made based on work item quantities and unit costs from contracts and bid proposals for SCS funded construction in the state during the past 10 years. The August 1985 bids from Napili 2-3 sediment control structure of Honolua Watershed Project which is currently under construction 12 miles to the north of the Lahaina area were heavily relied upon. The unit costs were updated to 1990 costs using the ENR Construction Cost Index. The unit costs were reviewed by the Hawaii SCE.

Quantities for each work item were calculated for the five project reaches through the preparation of low and medium intensity engineering designs. A computerized spreadsheet was used to calculate and sum the resultant costs.

Flood protection construction costs were allocated to PL-566 funds. Some construction costs, including relocation of utilities and pipelines and construction of road crossings for the sugar company roads, were assumed to be land rights costs and were allocated to sponsor funding.

An additional 15% was added to the construction costs for contingencies. Engineering services costs were estimated at 15% of total installation and administrative services costs at 8% and were apportioned to the two funding sources. Although an analysis of the fraction of engineering and adminstrative costs for past SCS contracts was not conducted, the rates that are used are similar to those used for other SCS projects of like nature and magnitude.

The cost of acquisition of rights of way were estimated by examining present land use and proposed land use in the project area. Right of way costs were allocated without contingency to sponsor costs. Relocation assistance costs were apportioned by the ratio of the costs borne by the two funds.

Unit costs were first developed in 1986. Costs were updated to 1990 levels by using the Engineering News Record construction cost index. Most construction cost items were increased by 11 percent at that time.

A 50-year project evaluation period was used. Three years for installation is assumed. Construction costs were discounted to present value for year zero and a 8-7/8% discount rate with 50 year amortization was used to to compute the annualized installation cost.

Operation, Maintenance and Replacement (OM&R) costs were estimated by summing manpower and equipment costs for items of work such as adminstration, inspection, vegetation control, and trash clearing. Percentages of installation cost were used for periodic maintenance of structures and replacement of structural work.

Total annualized cost include the annualized installation cost and annualized OM&R cost.

The summary of installation costs for the selected plan is shown as Table 4 below. The variation between the total cost shown below and that used in the Plan-EA is due to rounding.

Table 4

27-Aug-90
COSTSHEET
LAHAINA WATERSHED PROJECT - ALTERNATIVE 3 - 50 YR
TOTAL COSTS

CONSTRUCTION ITEMS	UNITS	NO. UNITS	UNIT COST	TOTAL COST
CLEAR AND GRUB	L.S.	1	11000	11000
MOBILIZATION	L.S.	1	44000	44000
POLLUTION CONTROL	L.S.	1	33000	33000
STRUCTURE REMOVAL	EA.	5	5500	27500
EXCAVATION, UNCLASSIFIED	CU.YD.	158132	5.50	869726
EARTHFILL, COMPACTED	CU.YD.	37413	11	411543
CONCRETE, CLASS 4000	CU.YD.	3209	300	962550
STEEL REINFORCING	LB.	362065	0.75	271549
EPOXY COATED REINF. STEEL	LB.	42926	1.50	64389
RIPRAP, LOOSE	CU.YD.	755	55	41525
RIPRAP, GROUTED	CU.YD.	503	165	82995
DRAINFILL AND BEDDING	CU.YD.	1927	82	158014
DRAINLINE	LN.FT.	2608	11	28688
CHAINLINK FENCING	LN.FT.	5243	12	62916
VEGETATIVE COVER	AC.	13.59	13200	179388
ASPHALT BASE REM./REPLAC.	SQ.YD.	0	38	0
PIPELINE RELOCATION	L.S.	1	66000	66000
FIELD OFFICE	L.S.	1	16500	16500
STRUCT. REM. (RC)	CU.YD	89	250	22250
STRUCT. REM. (NON-RC)	CU.YD.	1503	50	75150
SUBTOTAL				3428683
CONTINGENCY (15%)				514302
CONSTRUCTION COST				3942985
ENGINEERING COST (15%)				591448
ADMINISTRATIVE COST (8%)				315439
RIGHT OF WAY COST (AG.)	AC.	20.44	35000	715400
RIGHT OF WAY COST (RES.)	AC.	0	500000	0
HOUSEHOLD RELOCATION	EA.	5	50000	250000
TOTAL PROJECT COST				5815272

COST SHARE ITEM	PERCENT PL-566	PL-566 COST	LOCAL COST	TOTAL COST
CONSTRUCTION/LAND RIGHTS	96	3799417	176589	3976006
ENGINEERING	100	569913	0	569913
ADMINISTRATION	50	151977	151977	303953
RIGHT OF WAY	0	0	715400	715400
HOUSEHOLD RELOCATION	81	202500	47500	250000
TOTAL COSTS		4723806	1091466	5815272

INVESTIGATION AND ANALYSES

ENVIRONMENTAL ANALYSIS

General

The environmental analysis was a continuing process throughout the planning process. The process consisted of the following steps:

1. Scoping of Concerns -- Environmental and cultural resources are identified and existing data collected.

2. Preliminary Assessment -- Those concerns that may be significantly impacted by the project are identified.

3. Detailed Investigation/Inventory -- Field investigation or inventory of those concerns identified in the Preliminary Assessment is conducted to develop an adequate information base.

4. Detailed Assessment -- Determination of the impacts of the project is made.

The analysis began by contacting the various State and Federal agencies responsible for natural and cultural resources management and requesting assistance in determining any impact on the environment due to the installation of alternatives to alleviate the flooding, erosion and sedimentation problems in the area. The "scoping of concerns" utilizing government agencies has proven to be a satisfactory arrangement in previous SCS planning projects as working relationships with mutual understanding of agency priorities have been established.

Where concerns were raised, specialists were called upon to develop field data and to make an assessment of the impacts of the project on the resource.

Public meetings and meetings with the sponsors were held identify concerns and to discuss the environmental impacts of the alternatives.

Environmental Concerns

Marine Resources

From the outset, project planners were aware that a major concern was the effect on the coastal environment near the area where the diverted flood waters would enter the ocean. SCS contracted for a study of the effects of flood waters on the coastal environment and the conclusions were used to consider outlet locations that would have the least effect.

An assessment of potential marine ecological impacts of the Lahaina Watershed project was conducted in 1982 and 1983, by Dr. Richard W. Grigg, Associate Marine Biologist, University of Hawaii. The contract involved assessing the potential ecological impacts within the fringing reef

fronting Lahaina Town and at the stream mouth of Kauaula Stream. Dr. Grigg concluded that the potential environmental impact to the marine environment at the Kauaula Stream mouth would be considerably less than than to the nearshore reef area fronting the Town.

Another purpose for conducting the marine study was to establish a baseline against which changes to the marine environment caused by installation of the project could be assessed.

A second marine ecology assessment was conducted by Dr. Grigg in 1986, regarding nearshore sites to the south of Kauaula Stream in an effort to identify a second outlet site. One of the preliminary alternatives that was considered employed a second outlet to raise the flood prevention level of protection while retaining the existing bridges and outlet channel for Kauaula Stream. The supplemental assessment concluded that a second outlet approximately 3,000 feet to the south would be preferable. The preliminary alternative with two outlets was judged to be too costly and was dropped from consideration.

Biological Resources

Following project authorization, assessment of biological resources in the project area was conducted at a reconaissance level through inquiries to responsible Federal and State agencies. In October 1985, letters were sent to the U.S. Fish and Wildlife Service, State Division of Aquatic Resources, and the State Division of Forestry and Wildlife requesting assistance to identify impacts to biological resources in the Lahaina watershed. Dr. Grigg's marine assessment was also made available to the agencies.

The U.S. Fish and Wildlife Service concurred with Dr. Grigg's findings and recommendations. In addition, Fish and Wildlife Service recommended that sediment control measures be utilized to minimize sediment discharge to the ocean.

The State Division of Aquatic Resources responded that although use of the Kauaula outlet would "probably harm marine life less" than discharge near the boat harbor, sediment and nutrient loading of the deeper water off Makila Point may impact coral and glass bottom tour boat operation. Comment from the tour boat operators was recommended.

The State Division of Forestry and Wildlife responded that the "project area lies well outside the forested and wildlife areas of the watershed." The Division of Forestry and Wildlife foresaw no impact to forestry or wildlife due to the project.

An further assessment of biological resources was conducted by SCS staff.

There are no undisturbed natural areas in the lower part of the Lahaina Watershed that will be affected by project installation. The diversion channel alignment is now used for sugarcane cultivation and associated roads, ditches, and vacant land. The benefitted area below the diversion is in agricultural and urban uses. Vegetation in the lower watershed consists predominantly of introduced species. Of the native plant species,

including the endemic wiliwili (Erythrina sandwicensis) and 'anunu, none are considered rare, threatened, or endangered by either federal or state governments.

There are no identified threatened or endangered species of animal within the watershed.

Fish habitat in the Kauaula Stream is limited to the lower reaches where there is tidal backwater in the existing concrete outlet channel.

The wildlife habitat is limited to the sugarcane fields and the vegetated area along the Kauaula Stream. These areas are habitat for rats and mice. The Hawaiian owl, or pueo (Asio flammeus sandwichensis) may frequent the area because of the likelihood of rats and mice inhabiting the sugarcane fields.

The proposed alternative will require approximately 18 acres of agricultural land for the installation of the floodwater diversion channel. The vegetated earth diversion channel will restore approximately 13 acres of similar habitat.

Cultural Resources

Consultation with the State Office of Historic Preservation was begun in 1985 with a request for assistance to determine possible impacts to historic or cultural sites due to installation of the project.

A review of the Division of State Parks and Historic Sites indicates that the Lahaina Watershed project installation does not occur on historic properties that are listed on the Hawaii Register or the National Register of Historic Places, or that have been determined eligible for inclusion on the National Register of Historic Places. Project improvements will be as close as one-half mile from the Lahaina Historic District (site #3001) and Hale Pa'i (site #1596), sites listed on the National Register of Historic Places.

A field inspection of the proposed floodwater diversion, sediment basins, debris basin, and outlet channel sites were made by Wendell Kam, Staff Archaeologist of the State Historic Sites Section, in March 1986. The field inspection resulted in the determination that the project will have no adverse effect on the Lahaina Historic District. The Lahaina historic sites will receive a 50-year level of flood protection.

A physical inspection of the proposed floodwater diversion alignment, also conducted by W. Kam in March 1986, resulted in a negative finding of any evidence of significant cultural resources along the proposed route which has been extensively disturbed and modified by sugarcaone production since the 1860's. In the event that any previously unidentified sites or remains are uncovered, work will be stopped in the immediate area and the State Office of Historic Preservation will be notified. The State Historic Preservation Officer will "assess the impact and will make recommendations for mitigation activity, if warranted."

The installation of the diversion channel may require the removal of up to five homes in Wainee Village. The houses may be characterized as "plantation camp" houses. Thousands of such homes were constructed by the plantations throughout Hawaii to house workers during the pre-World War II period.

Through consultation with the SHPO, it was determined, in September 1989, that 1) Wainee Village meets the criteria for historic sites and 2) the homes affected by the project have little historic value due their peripheral location and extensive alterations. Any demolition of these houses will be accompanied by recording and documentation of the structure as may be required by the State Historic Preservation Office.

Forestry

Letters were sent to both the U.S. Forest Service and the State Division of Forestry and Wildlife requesting assistance to identify possible impacts to forest resources due to installation of the project. Their response indicates there will be no impact (positive or negative) resulting from this project on forest resources in the area.

Important Agricultural Land

There are 205 acres of prime agricultural land and 1100 acres of other important agricultural land in the watershed area. Eight acres of prime agricultural land will be lost as a result of the project.

Consultation with The Pioneer Mill Company, operator of the affected farmland, has been ongoing. The impact of the conversion of agricultural land to flood prevention purposes is not significant.

Visual Resources

The scenic beauty of the Lahaina area is an economic asset that should be maintained. Although the proposed works of improvement will be visible from many locations in the Lahaina area, significant adverse impact should not exist. The earth diversion and its embankment will be visible from the town area. The grassed embankment will blend into the agricultural landscape when it is not screened by mature sugarcane.

The most visible component will be the debris basin on Kauaula Stream approximately 200 feet above Honoapiilani Hwy. In form, the basin embankment will resemble the many rockpiles in the area that have been created by sugarcane cultivation operations. Vegetative screening and use of architectural textures and colors for concrete works will minimized its visual impact.

Viewscape modelling of the project improvements using a U.S. Forest Service computer program called "New Perspectives" was attempted in 1986, in Portland, OR. Coarse line drawings of existing and after installation views of the diversion and debris basin were produced on a pen plotter. Although the technology appeared promising, the effort was not followed through due to time and cost constraints.

Conclusion

Throughout the planning, environmental impacts of the proposed alternatives were considered. Meetings with the sponsors, the public, private industry, and state and county agencies were held to ascertain and evaluate environmental effects that may result from project implementation. No significant concerns that could not be satisfied or objections to the project emerged through the planning meetings.

As a result of reviewing the data and the public meeting notes, it was determined by SCS that the priject will have no significant impact on the human environment and that a "findings of no significant impact" be filed for this project.

INVESTIGATION AND ANALYSES

PUBLIC PARTICIPATION

Public participation in the planning process assures that concerns of the citizens, groups, and agencies affected by project implementation receive careful consideration and are incorporated into the plan where possible. The request for federal assistance to relieve flood problems in Lahaina was received from the West Maui Soil and Water Conservation District and the County of Maui in November, 1980. A series of scoping meetings with the sponsors, agencies, and the public was begun in late 1981.

An informal workshop was conducted on September 12, 1981, at the Lahaina Civic Center, where individualized interchange between SCS staffers and the public was made possible. Several meetings with groups, such as the major land users, landowners, and the Puamana Subdivision residents, were held in 1982 and 1983. It was through such meetings that the basic plan to provide flood protection was developed. A history of flooding and the resulting losses was established to describe the existing conditions for the Preauthorization Report. Input from Pioneer Mill Co. and AMFAC Properties helped determine the future condition senario incorporating Pioneer Mill's cultivation plans and needs and AMFAC Properties' development plans

Planning Authorization was granted by SCS National Headquarters on March 18, 1985. During that year a concerted effort was made to contact the major groups and agencies that would be affected by the project or had jurisdiction over any aspect of the project. Consultation with the following agencies and individuals was begun 1985:

Hawaii Division of Water and Land Development
Hawaii Office of Historic Preservation
Hawaii Division of Aquatic Resources
Hawaii Division of Forestry and Wildlife
Hawaii Department of Planning and Economic Development
(now the Hawaii Office of Planning)
Senator Daniel K. Inouye
Senator Spark M. Matsunaga
Representative Daniel K. Akaka
U.S. Army Corps of Engineers
U.S. Fish and Wildlife Service
U.S. Forest Service.

A Public Meeting was held at Kamehameha III School on the evening of December 3, 1985. At the widely publicized meeting a preliminary plan to provide flood control was described and the attendees were asked to voice their comments and concerns. It appeared that sediment discharge was a major concern of the attendees. They supported measures to decrease sediment discharge to the reef area. A letter responding to their voiced concerns was prepared and mailed to the attendees.

Following the development of alternative plans for flood protection a Public Meeting was held at Kamehameha III School on July 2, 1986. Four plans were described that offered varying levels of protection and one

alternative having two outlets. The engineering works, constraints and costs were described. The economic analysis for the project was described. Benefit-cost ratios were provided for each alternative. The attendees were polled on the alternatives. The group recommended the 50-year level of protection alternative which also offered the highest B:C ratio.

On July 20, 1989, after plan selection and near the completion of the draft Plan/EA, a public meeting was held in Lahaina to describe the forthcoming report. Comments and questions from the audience indicated support for the project.

Upon completion of the Draft Plan/EA the agencies and individuals listed in the Consultation and Public Participation section of the Plan/EA will be sent review copies.

EVALUATION OF CONCERNS

The identification and evaluation of concerns was an ongoing process through the development of the watershed plan. Community concerns were elicited through public meetings, meetings with local organizations, and through personal contact by West Maui SWCD members. The planning staff, in consultation with the SWCD, County of Maui, and the SCS Wailuku Field Office, developed a list of concerns voiced by the local community. Also incorporated into the list were the environmental and cultural concerns that are normally taken into account during environmental assessment.

Most of the concerns that warranted attention related to the flood problem or the flood-borne sediment. Loss of property or income due to flooding and sediment damage was, perhaps, the most significant concern. The stoppage of business and services in Lahaina Town due to flooding was another major concern. The threat to human safety was also expressed. Many people in the tourism industry expressed concerns about the adverse effects of floods and sediments to the ocean environment and the resulting loss of revenue.

All of the concerns expressed by the community that were affected by the installation of the watershed plan were accorded a "high" degree of significance to decisionmaking. Those concerns that remain unaffected by any of the alternative watershed plans or were not existent in the watershed were determined to thave a "low" or "none" ranking.

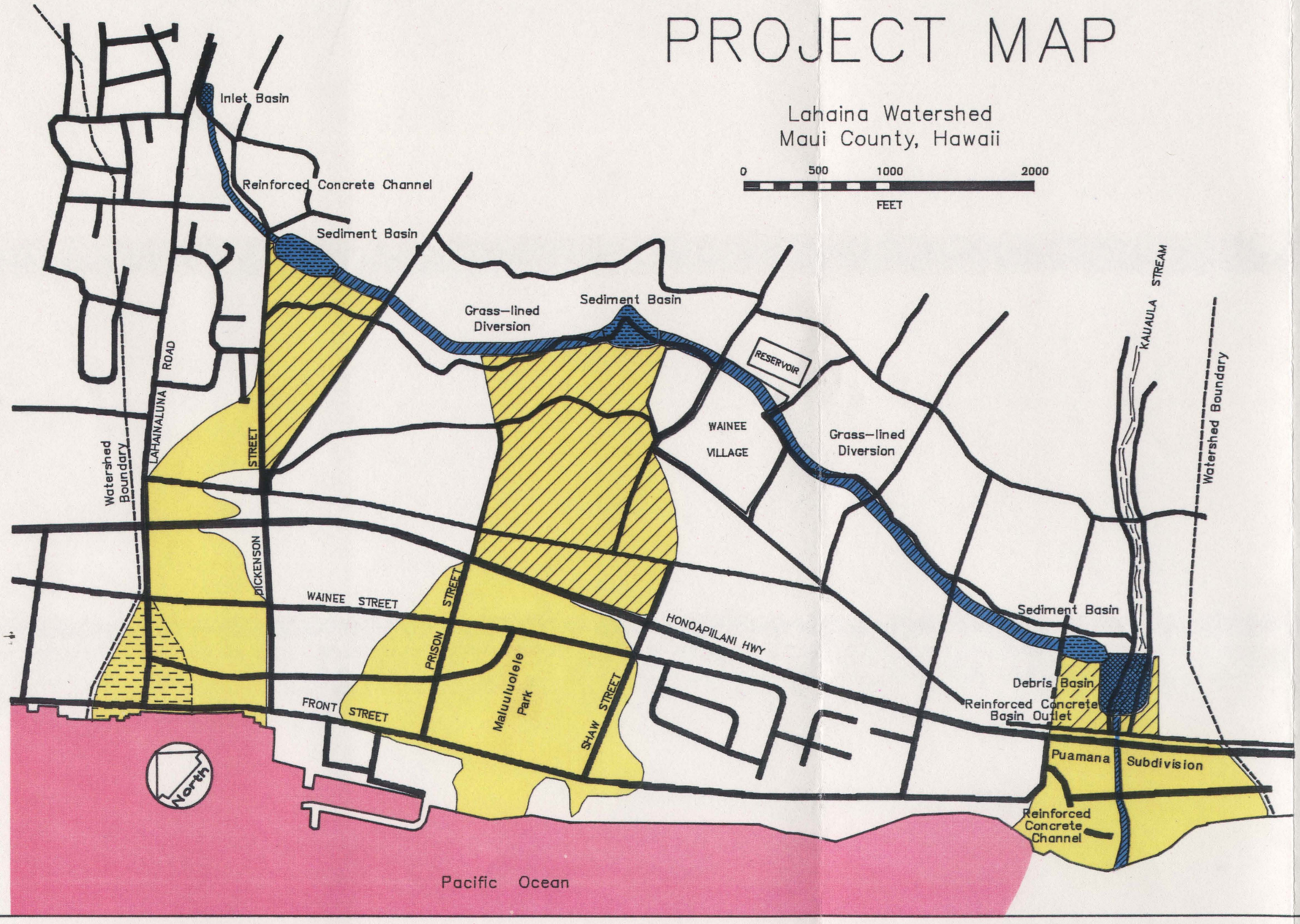
APPENDIX D

Project Map

PROJECT MAP

Lahaina Watershed
Maui County, Hawaii

0 500 1000 2000
FEET



LEGEND

BENEFITTED AREAS

- Urban
- Agriculture
- Common Floodplain
- Nearshore Reef

CHANNEL WORK

Lahaina Watershed

N
Not to Scale